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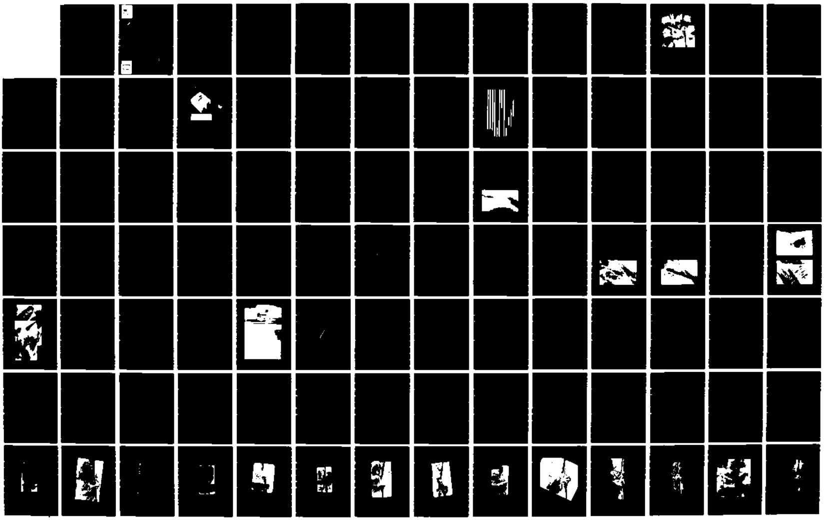

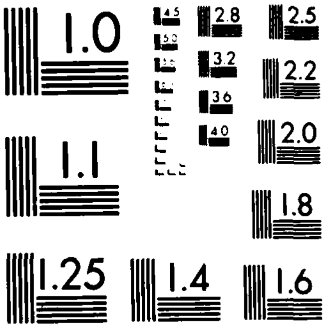

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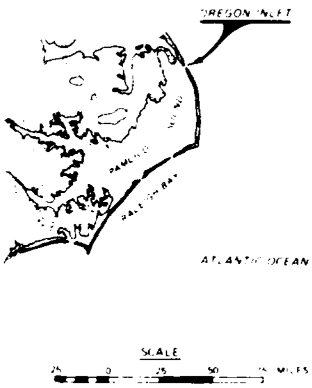

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TECHNICAL REPORT HL-83-10

FUNCTIONAL DESIGN OF CONTROL STRUCTURES FOR OREGON INLET, NORTH CAROLINA

Hydraulic Model Investigation

by

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US ARMY ENGINEER WATERWAYS EXPERIMENT STATION

June 1983
Final Report

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Oregon Inlet, the northernmost inlet through North Carolina's barrier islands known as the "Outer Banks," is a natural channel conducting flow between the Atlantic Ocean and extensive open bay sounds. As is typical of many natural inlets, navigation through the inlet can be dangerous due to shallow shifting sand shoals. The necessity of continued maintenance dredging and the exposure of commercial and private craft to shoaling and breaking waves indicate that inlet stabilization by jetties is desirable and should be investigated.

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20. ABSTRACT (Continued)

The design study for the Manteo (Shallowbag) Bay Project included construction and testing of a physical model of Oregon Inlet. Model scales were 1:300 horizontally and 1:60 vertically. The model reproduced 12 square miles of ocean area to the 60-ft-depth contour and 17 square miles of Pamlico Sound. Initially, the model was molded of concrete; however, during the latter phase of the study, the entrance channel and vicinity were removed and molded with crushed coal for a movable-bed study. An extensive set of field data was collected and analyzed for use in model verification. The verification process indicated that tidal velocities and elevations were in satisfactory agreement with the prototype and the model could be reliably used as a predictive tool to investigate the effect of various jetty lengths, alignments, and spacings on flow conditions through the inlet and on tidal variations within Pamlico Sound.

Model testing included the study of jetty alignment, length, and spacing and the effects of the jetty structures on tidal exchange and on the flow through Bonner Bridge. Also, steady-state ebb and flood storm surges were reproduced and the effects of the jetties on these flows examined. Staged jetty construction tests aided in determining the best construction sequence to limit excessive scour velocities. Sediment tracer tests indicated the shape and size of fillet development adjacent to the jetties. The movable-bed tests provided information on the effects of jetties on channel alignment for both normal tides and during storm surge conditions. The effects of bottom protection at the Bonner Bridge and the placement of sills in Davis and Middle Sloughs also were evaluated.

It was concluded that the plan 2 jetty alignment with 2,500-, 3,500-, or 5,000-ft spacing would not negatively impact the tidal exchange, storm surge flows, or flow through Bonner Bridge. However, the larger spacings may permit bifurcation of the entrance channel or a more curvilinear channel.

PREFACE

The model study described in this report was authorized by the U. S. Army Engineer District, Wilmington (SAW), in July 1974. The study was conducted in the Wave Dynamics Division of the Hydraulics Laboratory, U. S. Army Engineer Waterways Experiment Station (WES), during the period July 1974 through September 1979 under the general direction of Mr. H. B. Simmons, Chief of the Hydraulics Laboratory; Mr. F. A. Herrmann, Jr., Assistant Chief of the Hydraulics Laboratory; Dr. R. W. Whalin, former Chief of the Wave Dynamics Division; and Mr. C. E. Chatham, Acting Chief of the Wave Dynamics Division. Tests were conducted by Mr. N. W. Hollyfield and data analyses were performed by Messrs. Hollyfield and W. C. Seabergh, project engineers, and Mr. J. W. McCoy, engineering technician. This report was prepared by Messrs. Hollyfield, McCoy, and Seabergh.

Messrs. L. Vallianos and T. Jarrett of SAW were actively involved in the model study and attended several conferences at WES during the course of the investigation.

SAW District Engineers during the model study and report preparation were COL Albert C. Costanzo, COL Homer Johnstone, and COL Adolph A. Hight.

Commanders and Directors of WES during the study and the preparation and publication of this report were COL John L. Cannon, CE, and COL Nelson P. Conover, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
cubic feet	0.02831685	cubic metres
cubic feet per second	0.02831685	cubic metres per second
cubic yards	0.7645549	cubic metres
feet	0.3048	metres
feet per second	0.3048	metres per second
inches	25.4	millimetres
miles (U. S. statute)	1.609344	kilometres
square feet	0.09290304	square metres
square miles (U. S. statute)	2.589988	square kilometres

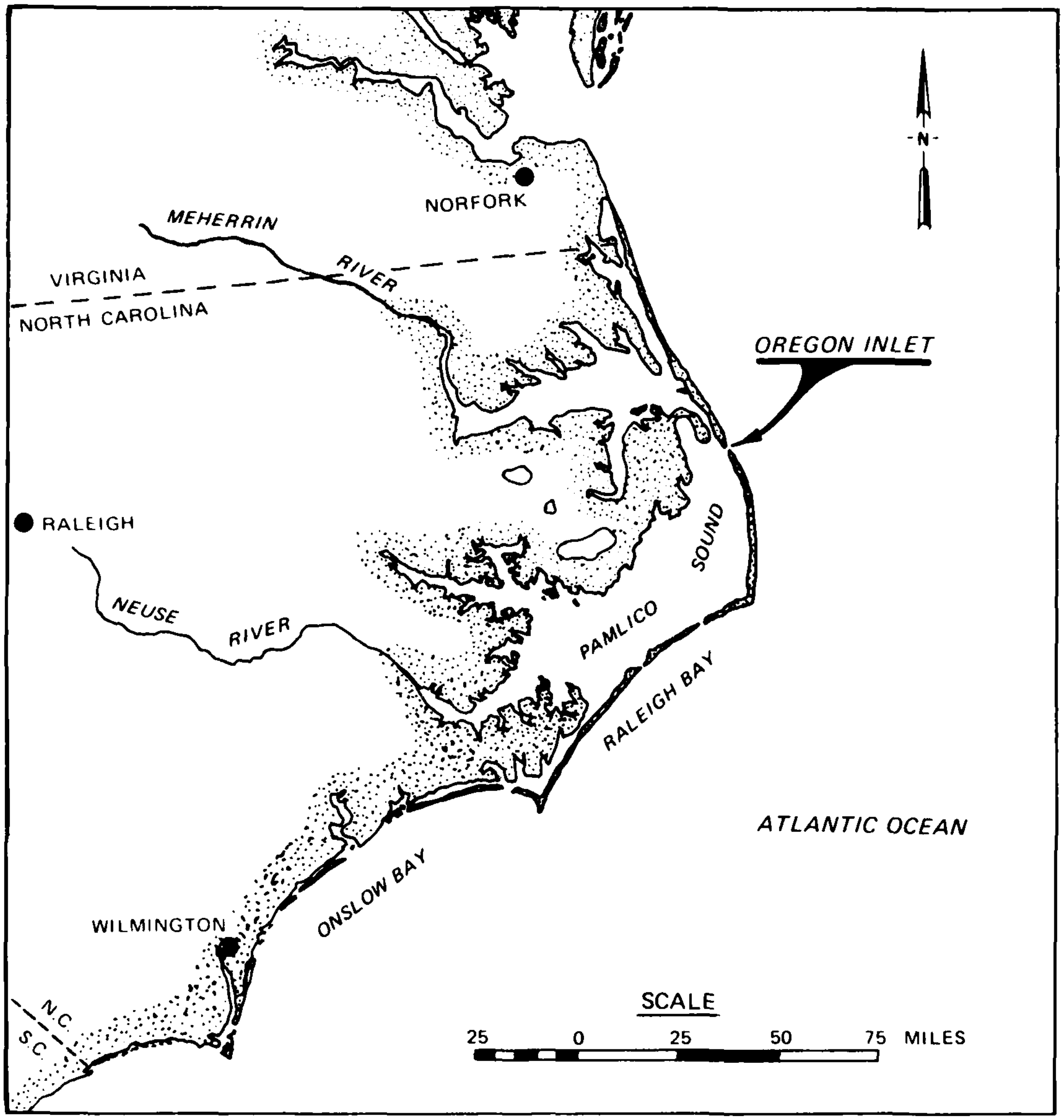

Figure 1. Location map

FUNCTIONAL DESIGN OF CONTROL STRUCTURES FOR OREGON INLET, NORTH CAROLINA

Hydraulic Model Investigation

PART I: INTRODUCTION

The Prototype

Location

1. Oregon Inlet, North Carolina, is located approximately 80 miles* south of Norfolk, Virginia. It is the northernmost inlet through the barrier islands known as "the Outer Banks." The next opening in the Outer Banks south of Oregon Inlet is Hatteras Inlet. All of Currituck, Albemarle, Croatan, and Roanoke Sounds and the north end of Pamlico Sound are tributaries to Oregon Inlet. Figure 1 shows the location of the inlet.

2. There has been an opening in the Outer Banks near the present location of Oregon Inlet for at least 400 years. The inlet may have closed for short periods during the 400 years, but it has been open continuously for about the last 130 years. A history of Oregon Inlet appears in a General Design Memorandum, Phase 1 (USAED, Wilmington 1980). Figure 2 shows the inlet in October 1976.

Physical characteristics

3. The tide range in the gorge of Oregon Inlet has a mean value of 1.8 ft. The tide range of the bay, or sound, is relatively small compared with the ocean range and is 0.5 ft. This reduction is due to the broad expanse of bay the inlet serves and to extensive shoals surrounding the inlet channel in the bay which attenuate tidal energy. As a result of the broad open expanse of bay, wind stress effects can dominate the movement of water in the sounds and through the inlet. A setup of bay water level can effectively produce long-term ebb flows through the inlet, and bay setdown can induce long-term flood flows of up to a few days duration. The normal tidal prism (or exchange of water between ocean and bay during a tidal cycle) is 3×10^9 cu ft.

4. Estimates of littoral drift for the inlet are as high as

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* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.

Figure 2. Oregon Inlet, 21 October 1976

1,380,000 cu yd/yr from the north and 1,010,000 cu yd/yr from the south (USAED, Wilmington 1968). It is believed that storms are very important in the inlet's morphology, with the largest waves arriving from the northeast. Northeast winds would probably produce a setdown of water level in the sound behind the bay, producing flood current predominance in the inlet (Glassen 1971) and thus coupled with the movement of long-shore currents from the north, would move large amounts of sediment into the unprotected inlet causing high rates of channel shoaling.

5. Another aspect of importance to the inlet region is the Bonner Bridge which crosses Oregon Inlet connecting Bodie and Pea Islands (Figure 2).

The 2.43-mile-long structure is supported on concrete piles from 30 to 75 ft in length. The Bonner Bridge includes a 130-ft-wide navigation span, and any modification to the inlet must consider its effect on the flow approaching the bridge. In the last few years, there has been severe scouring in regions away from the navigation span that has caused settlement of the bridge.

Purpose and Scope of Model Study

6. Oregon Inlet is typical of many natural inlets in that navigation through the inlet can be dangerous, as evidenced by numerous occurrences of damage sustained by fishing vessels and the fact that commercial fishing vessel insurance underwriters do not consider Oregon Inlet an approved watercourse (USAED, Wilmington 1968). The shallow shifting shoals over the bar and the necessity of continued maintenance dredging indicate that stabilization of the inlet by jetties is desirable and should be investigated as a possible solution to problems at the inlet.

7. Physical model studies concerning Oregon Inlet conducted at the U. S. Army Engineer Waterways Experiment Station (WES) have included a structural stability study for jetty design, a floating breakwater study to provide protection for dredging, and the functional study described in this report. Also, numerical studies of storm surge and beach processes have been performed at WES for the Oregon Inlet region. The purpose of the functional model was to investigate flow control characteristics of the proposed jetty system. Important design parameters and other considerations that needed to be investigated included:

a. Optimum jetty alignment and spacing between jetties.

b. Determination of the required minimum length of jetties.

c. Navigability of the inlet with respect to eliminating adverse flow conditions, particularly in areas such as the navigation gap at Bonner Bridge, and maintaining a channel centrally located with respect to the jetties.

d. Maintaining or improving the average existing natural flow exchange between the ocean and the bay.

e. Maintenance of a horizontally stable channel, especially with respect to the channel at the navigation gap at Bonner Bridge. This is important as the navigation gap is the only section of bridge with overhead clearance necessary to satisfy waterway

requirements, and also other portions of the Bonner Bridge do not have supporting structural piles long enough to accommodate natural main channel depths.

f. Effects of storm surge water levels on flow through the jettied inlet (i.e., it was desirable to prevent any increase in storm surge elevations near the inlet).

g. Qualitative indication of wave heights in the entrance channel and deposition basin.

h. Qualitative indication of regions of scour and fill in the entrance channel.

i. Current patterns during construction.

j. Effect of Bonner Bridge bottom protection on hydraulics (i.e., it is desirable to prevent any bottom scour beneath the Bonner Bridge).

k. Qualitative study of movement of longshore drift with sediment tracers.

8. The above design considerations were investigated with a combination fixed-bed and movable-bed physical hydraulic model molded to the bathymetry of the inlet region. The model had the capability to define hydraulic effects by measurement of velocities and tidal elevations and by photography of surface current patterns. The study also included sediment tracer tests which were conducted using a lightweight plastic to simulate sand movement and which gave qualitative comparisons of the proposed jetty plan with existing conditions. Also a movable bed of crushed coal gave qualitative indications of the effects of the jetties on channel orientation.

PART II: THE MODEL

Description

9. Geometric scale ratios (model to prototype) of 1:300 horizontally and 1:60 vertically were chosen for the model. The choice of the horizontal scale was influenced by the size of the test facility that was available. Using the chosen geometric ratios, the following scale factors were computed from the Froudian law of similitude.

Characteristic	Scale Ratio
Horizontal length	$L_H = 1:300$
Vertical length	$L_V = 1:60$
Area, surface	$L_H L_H = 1:90,000$
Area, cross sectional	$L_H L_V = 1:18,000$
Volume	$L_H L_H L_V = 1:5,400,000$
Velocity	$L_V^{1/2} = 1:7.746$
Discharge	$L_V^{3/2} L_H = 1:139,427$
Time, tidal wave	$L_H L_V^{-1/2} = 1:38.730$
Slope	$L_V / L_H = 5:1$

One prototype tidal cycle (semidiurnal) of 12.42 hr required 19.241 min of model time.

10. The model was constructed of sand-cement concrete. Aluminum templates were cut using hydrographic data from the May 1975 survey. The templates, located on 2-ft centers, were used as a guide in molding the concrete. Detail between templates was molded using key points from the map and sketching by hand. The ocean area was built to the 60-ft-depth contour and represented a prototype area of approximately 12 square miles. Wave generator pit area and model headbay areas occupied an area representing about 24 square miles. An area equivalent to about 17 square miles of the Pamlico Sound area was reproduced in addition to the storage areas representing portions of Pamlico and Roanoke Sounds along the rear sides of the model. A layout of the model is shown in Figure 3.

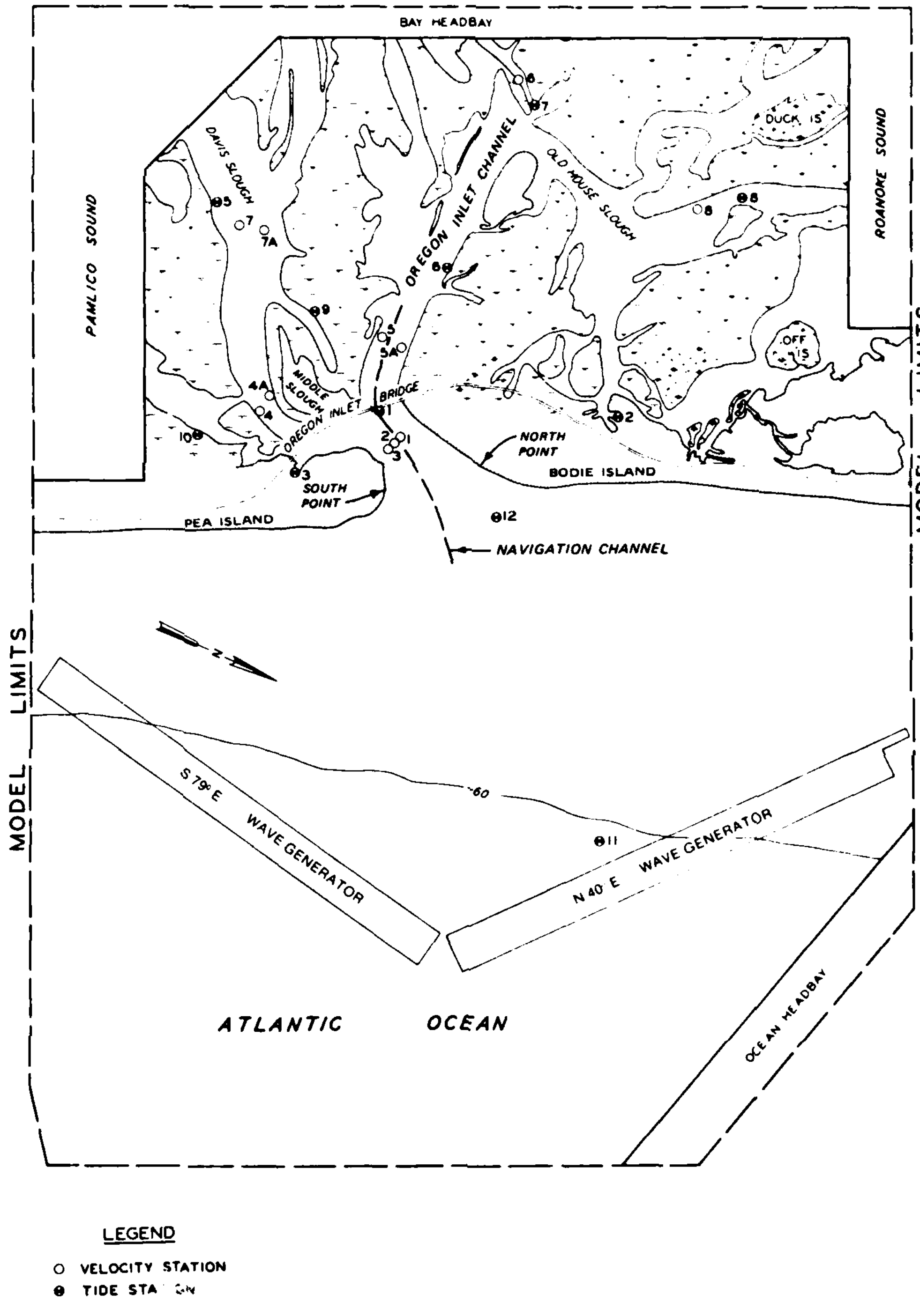

Figure 3. Model layout

Model Appurtenances

11. The model was equipped with devices to generate and control tides, measure water-surface elevations, measure velocities, take surface current and stop-motion photographs, and synchronize model events.

Tide generator

12. A pneumatic-hydraulic regulator was used as the principal component of the tide-generating system. Three types of programming devices were used during the study. A rotary potentiometer was used when a sine wave program of one tidal cycle (19.241 min to reproduce a 12.42-hr tide) in length was desired. The second type of programmer was a digital rotary drum switch. The drum switches could be used as programmers by themselves or could be used to modify a sine curve that was being generated by the sine potentiometer. The latter method was considered to be the better of the two since generation of most of the prototype tides required small deviations from the sine curve, and this method eliminated surging of the tide control that resulted from large digital changes of program.

13. The third type of program used a perforated paper tape that allowed sequences of up to 32 tidal cycles. For all three types of programmers, a feedback control loop was used; that is, a sensor was used to detect any difference between the actual water level and the programmed water level, and a control signal was generated to correct the difference.

Tide recorders

14. The tide-recording system consisted of Leopold and Stevens water-level sensing transmitters located at the gaging stations in the model and the companion recorders located in the instrument trailer. The transmitter "feels" the water with two needle probes, one 0.004 in. longer than the other. There is also a third common ground probe. The probe head is mounted on a precision screw that travels downward until the shorter probe touches the water, then the drive motor reverses until the longer probe reaches the water surface. The probes then oscillate about the water surface telemetering this movement to a recorder by selsyn motors.

15. Velocities were obtained by use of recording miniature Price meters (Figure 4). The cup diameter of the meters was 0.04 ft and the overall diameter of the cup assembly was 0.1 ft. When operating, the cup

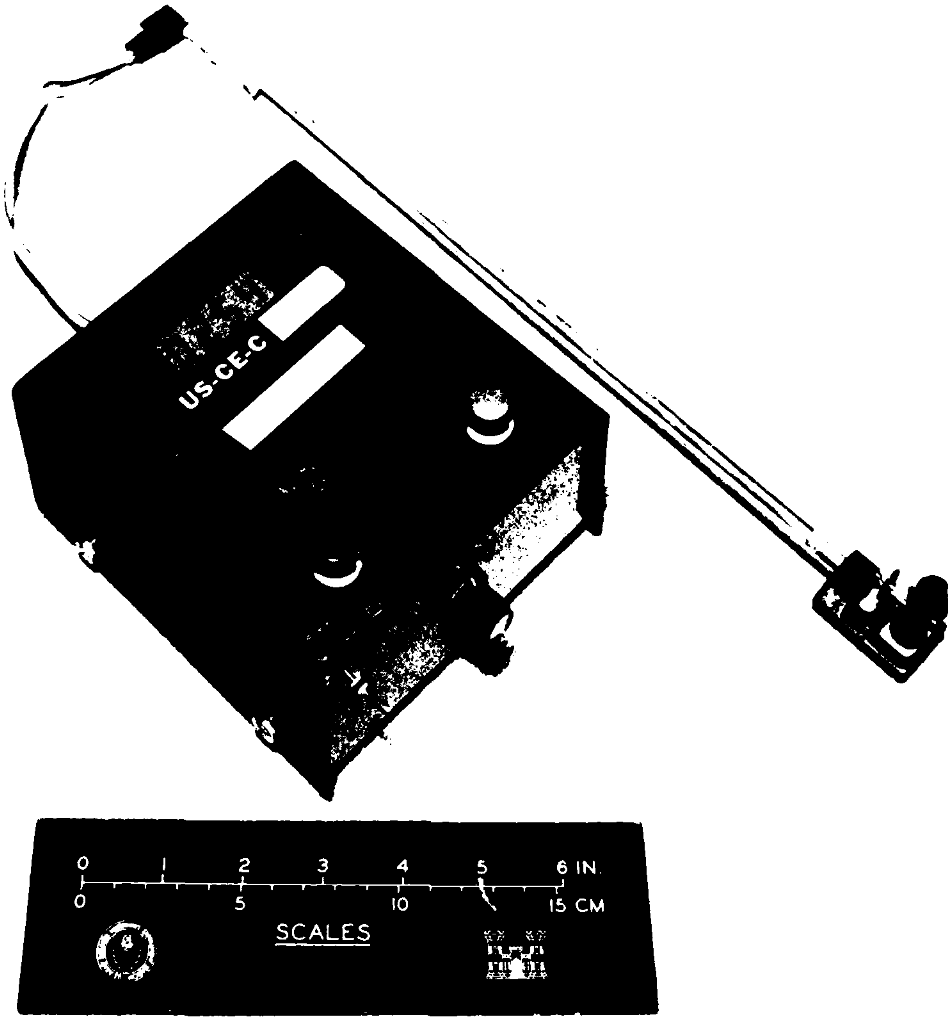

Figure 4. Miniature Price meter

assembly occupied a space equivalent to prototype dimension of 2 ft vertically and 30 ft horizontally.

Photographic system

16. A group of 8- by 10-in. cameras, fastened to catwalks about 14 ft above the model surface, were used to obtain surface current photographs. Wide-angle lens were used and the camera shutters were tripped simultaneously by an electronic timer. Time exposures were used so that confetti on the water surface traced patterns along the flow lines. Length of the flow lines defined the velocity magnitude. Some of the tests required stop-motion photography for which 16-mm movie cameras were used.

Accuracy of Model Measurements

Tidal elevation

17. Measurements of tidal elevations in the model were made with automatic telemetering transmitters and recorders. The degree of accuracy of this equipment is gaged by the difference in length of the probes that regulate the electronic circuitry. This difference is 0.004 in., which gives a model accuracy within 0.02 ft in prototype. However, the accuracy with which the chart can be read is from 0.05 to 0.1 ft. Therefore, tidal elevation data gathered on the model agree with the degree of accuracy of the prototype data of about 0.1 ft.

Velocities

18. Limitations of the current velocity meters used in the model should be considered in making close comparisons between model and prototype velocity data. The center line of the meter cup was about 0.05 ft above the bottom of the frame; therefore bottom velocity measurements in the model were actually obtained at a point 3.0 ft (prototype) above the bottom instead of about 2.0 ft as in the prototype metering program. Model velocities were determined by counting the number of revolutions in a 10-sec interval (which represents a period of about 6.5 min in the prototype), as compared with about a 1-min observation in the prototype. The horizontal spread of the entire meter cup wheel was about 0.11 ft in the model, representing about 33 ft in the prototype, as compared with less than 1.0 ft for the prototype meter. Thus the distortion of area (model to prototype) results in comparison of prototype point velocities with mean model velocities for a considerably larger area. The same is true for the vertical area, since the height of the meter cup was about 0.04 ft (2.5 ft prototype) relative to a few inches for the prototype meter. Calibrations and mechanical operation of the velocity meters, capable of measuring velocities to a minimum of 0.05 fps (0.4 fps prototype), were checked frequently during verification and testing to ensure accurate operation. Calibration of the meters is to ± 0.01 fps, which is about ± 0.07 fps prototype. The meter revolutions are counted to $\pm 1/4$ revolution during a 10-sec measurement period. This is equivalent to ± 0.02 fps or ± 0.15 fps prototype.

Discharges and flow volumes

19. The variance in velocity measurement causes a variance in

subsequent discharge and flow volume calculations. For example, for a cross-sectional area of 8,000 sq ft and a velocity of 3.00 $\pm$ 0.15 fps, the discharge would be some value between 22,800 and 25,200 cfs, any error in cross-sectional area notwithstanding. For flow volumes, consider an average ebb velocity of 1.50 $\pm$ 0.15 fps over a duration of 22,500 sec prototype (1/2 tidal cycle) and a cross-sectional area of 8,000 sq ft; the flow volume would be some value between 243 million and 297 million cu ft (i.e. 2.65 $\pm$ 0.26) $\times 10^8$ ft^3).

PART III: PROTOTYPE DATA AND MODEL VERIFICATION

Prototype Data

20. During the time that the Oregon Inlet model study was in the planning stage, several conferences were held in Rockville, Maryland, concerning prototype data collection. Representatives of the National Ocean Survey (NOS), U. S. Army Engineer District, Wilmington (SAW), and WES formulated a data collection program and the prototype data were collected with close cooperation between SAW, NOS, and WES. Funding for the effort was provided by SAW.

21. The NOS ship Ferrel was moved to Oregon Inlet around the first of May 1975 and berthed at the U. S. Coast Guard Station dock. Tidal current data were collected during the months of May and June 1975 using the Ferrel's tidal current survey system (TICUS), shown schematically in Figure 5. Eight buoys were used to obtain current data in the inlet area. Six of the buoys were deployed on stations that were monitored for the duration of the effort. These stations were numbered 1-6 (Table 1 and Figure 3 for locations of tidal current stations). The other two buoys were moved during the period so that additional stations could be covered. A bar graph, Figure 6, defines the period that current data were acquired at each of the stations. The data were recorded on magnetic tape at 0.1-hr intervals (6 min). Copies of the tapes are on file at NOS and SAW.

22. Prototype surface current circulation patterns were recorded on 20 and 21 May 1975. Gelatin capsules containing aluminum powder were dropped at various points in the inlet area from a small, slow-flying aircraft. After the gelatin dissolved, the aluminum powder formed a mirror-like patch on the water surface. The patches were photographed at 30-min intervals from high altitude overflights of a photoreconnaissance aircraft. Surface current velocities and directions were obtained by comparison of photographs made on each pass.

23. Prior to the time that the Ferrel went on station at Oregon Inlet, several tide gages had been installed in the inlet area. Table 2 lists the gages and their approximate geographic locations, and they are shown in Figure 3. The gages were in operation during the months of May and June 1975. The recorded tide data are on file at NOS and SAW. A second-order

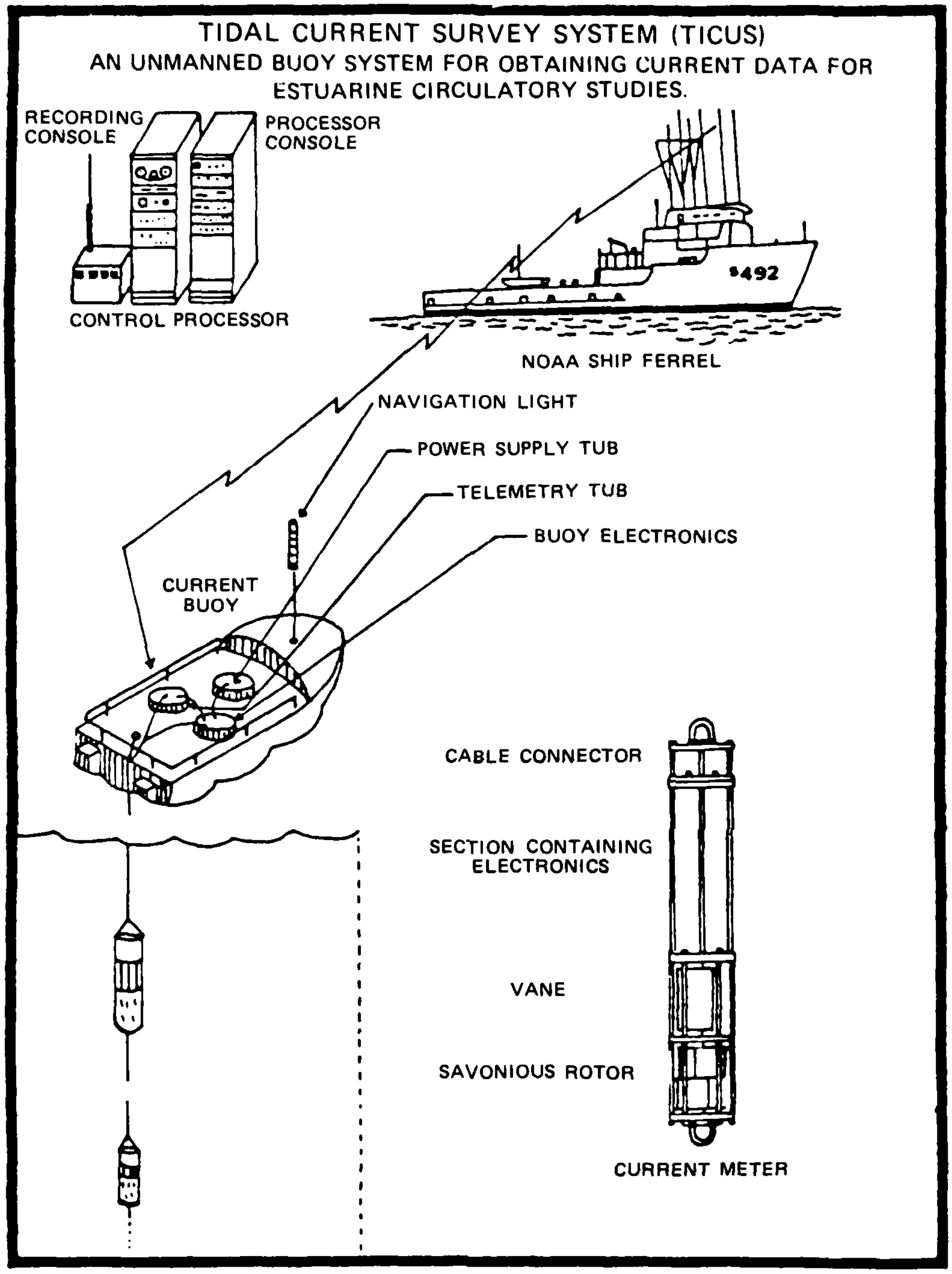

Figure 5. <u>Ferrel's</u> tidal current survey system

geodetic survey was run throughout the area to tie the gages together. Mean low water (mlw) datum and National Geodetic Vertical Datum of 1929 (NGVD) were obtained by NOS.

24. The entire area to be modeled was covered by available hydrographic and topographic maps. The ocean area between the -30 ft and -60 ft

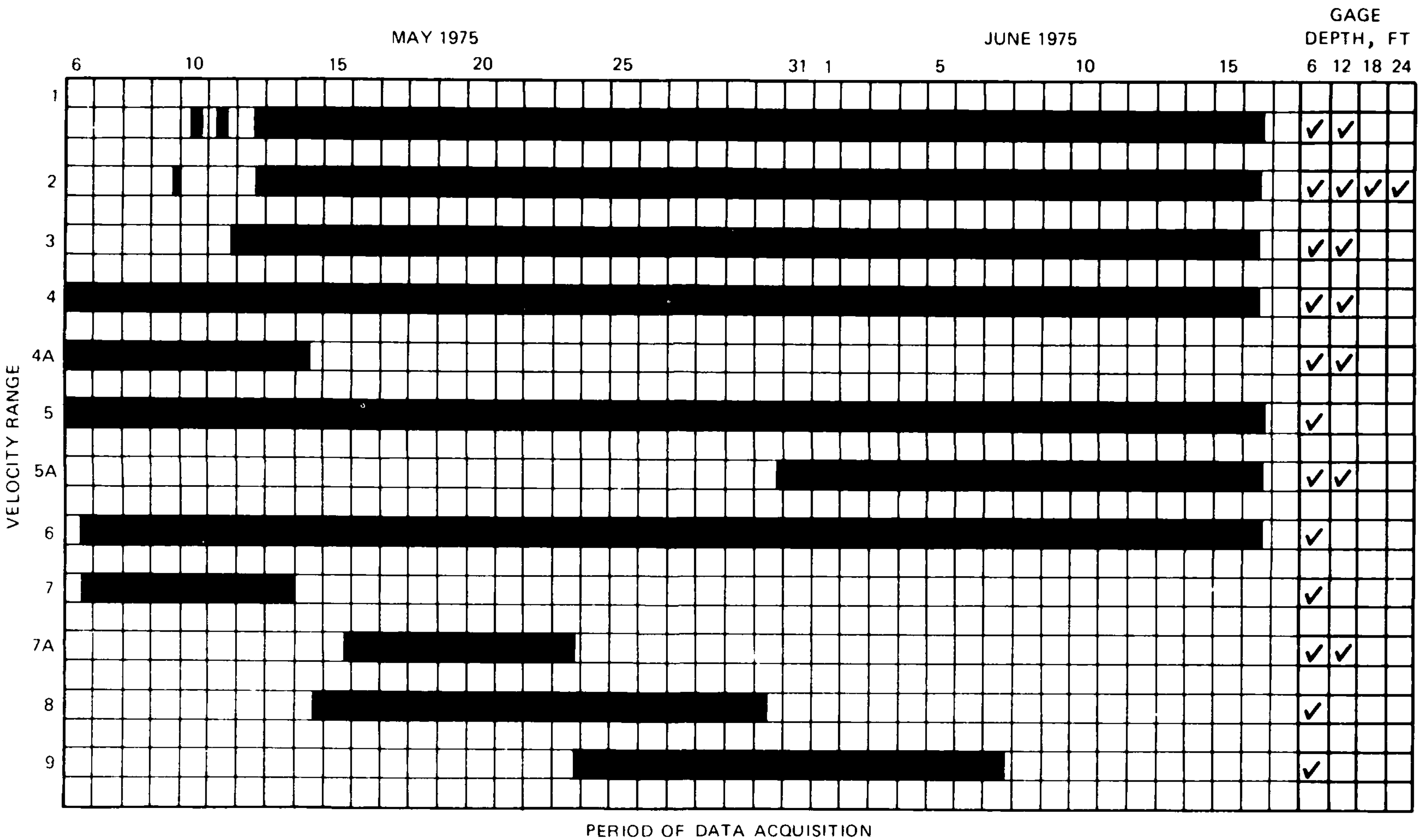

Figure 6. Time periods of current data acquisition

mlw contours was mapped on a scale of 1:10,000 with a 6-ft contour interval. Landward of the -30 ft mlw contour, the map scale was 1:5000 with a 2-ft contour interval. Topography for the land masses within the survey area was mapped on a scale of 1:5000 with a 2-ft contour interval. Hydrography and topography were referenced to mlw datum.

25. Mosaics were made from aerial photographs covering the area to be modeled. The time period covered by the mosaics was from January 1945 to October 1976. In the 30-year period, considerable changes have taken place. The instability of the inlet can be seen by examination of the mosaics in Photos 1-15.

Model Adjustment and Verification

26. Two segments of the prototype tide and velocity data were chosen for model adjustment and verification purposes. The basic time segment was the period between 0800 on 20 May and 2100 on 21 May 1975. That period was selected because the winds were low, tide heights and velocities at each of the stations were approximately the same at the beginning and end of the period, and prototype surface currents were defined by aerial photography during that period. The secondary period, 8 May through 23 May 1975, was selected to verify the long-term tidal response of the model.

27. Recording gages were installed in the model at the same respective locations as the prototype tide gages except for the Jennette's Pier gage which was beyond the model limits. One additional gage was added in the model (gage 11, Figure 3) to record the ocean tide. The prototype tide data for Jennette's Pier were programmed with the ocean tide control system. The bay side tide control was initially set to hold a level pool elevation, then the feedback gain control was set so that the response was dependent upon the flow into and out of the inlet. Through an iterative process, a control setting was achieved that resulted in the the proper tide range on the model boundary gages (gages 5, 7, and 8).

28. Using the adjustment described above for the ocean and bay tide generators, tests were made for the prototype 25-hr time period selected. After each test, adjustments were made to model roughness (vertical metal strips in the channels and crushed rock on the overbank) as dictated by comparison of model and prototype data. The ocean tide was modified slightly

early in the adjustment process. The modified ocean mean tide level was lower and the tide lagged when compared with the Jennette's Pier prototype gage. A difference between the two ocean gages was expected since the prototype ocean gage (Jennette's Pier) was located about 9 miles north of the inlet in relatively shallow water while the model ocean gage (gage 11) was located near the inlet in the model at a depth equivalent of 60 ft.

29. After adjustment of model roughness resulted in a fair reproduction of prototype tide elevation data, both elevation and velocity were recorded for each subsequent test. Subsequent changes in roughness were based on analyses of both tide elevations and velocities. Model elevations and velocities recorded after the last adjustment of model roughness are compared with the prototype in Plates 1-9. On the plots, positive velocities indicate flood flow and negative velocities indicate ebb flow. Model verification achieved in Plates 1-9 was considered to be very good.

30. The ability of the model to reproduce long-term tide data was verified by conducting tests for a 16-day period (8-23 May 1975). The model-to-prototype comparisons for that period are shown in Plates 10-17. The only significant differences occurred when there were prototype wind effects that cannot be simulated in the model.

31. Prototype surface current patterns were developed from photographs taken on 20 and 21 May 1975 and are shown in Plates 18-33. The model surface current photographs for the same dates and times are shown in Plates 34-49. The photographs were made as discussed in paragraph 16. Near the end of an exposure, an electronic flash unit was fired which produced a white spot near the end of the streak to indicate the direction of movement of the piece of confetti. A velocity scale on each plate can be used to determine velocity magnitude. The model reproduction of the prototype surface current directions and magnitudes is good except near shallow shoals near times of peak flow.

PART IV: THE TESTING PROGRAM

Base Tests

32. All dimensions used throughout the remainder of this report are prototype except as noted.

33. Prototype data used for model adjustment consisted of three tidal cycles of current velocities and tide heights. Each run of the three cycles required about 1 hr of model time. The data used to verify long-term tide reproduction were 31 tidal cycles in length and required almost 10 hr of model operating time. There were 12 prototype velocity stations, most of them with multiple depths; additional velocity stations were added on the model for the testing program, and their locations are shown on the figures describing the elements of the various plans tested. Measurement of model velocities was a time-consuming operation. With 12 stations, an average of two depths per station, and each point measured two times, 72 man-hours were required to acquire one set of velocity observations (while running the model adjustment tide data of three tidal cycles).

34. A base test condition was run in order to reduce model operation time for the remainder of the study. The model condition used for the base test was that which existed at the end of model adjustment and verification. The only change was in the ocean tide. Instead of the three cycles of prototype tidal data, a single sinusoidal wave was generated in the model ocean with a tidal range of 3.0 ft that NOS had determined as the mean tide range for the Jennette's Pier gage. Model data were obtained at each tide gage and velocity station. Graphs of these data were superimposed on plots of test results for comparison with each subsequent test.

35. Time-exposure photographs showing surface current flow lines and velocities were recorded for the normal tide and for simulated storm surges. For the normal tide, time exposures of 2.6 min were made at 1/30-cycle (24.84-min) intervals. Paths followed by Styrofoam confetti, which had been scattered on the water surface, were recorded on the time exposures. Photographs showing flow patterns and magnitudes at strength of ebb (time-step 1) and strength of flood (time-step 16) are shown in Plates 50 and 51.

36. Storm surges were simulated by programming the ocean and sound tide generators to maintain constant elevations that existed at the instant

of maximum head differential between the ocean and the sound, then allowing the flow to stabilize. Tide, velocity, and surface current pattern data were taken with steady flow conditions maintained. For simulation of the 12 September 1960 storm, the ocean and sound were maintained at -1.9 ft NGVD and 7.2 ft NGVD, respectively; for the 7 March 1962 storm, the respective elevations were 8.0 and 1.3 ft NGVD. Tide elevations were recorded at the locations shown in Figure 3, and velocity data were recorded at those locations and numerous other points including many points between piers of the Bonner Highway Bridge. A plot of base test velocities measured along the center line of the bridge was superimposed on plots of the data for subsequent tests. Time-exposure photographs showing surface current flow lines and velocities are shown in Plates 52 and 53.

Tests for Jetty Alignment 1

37. The first jetty system tested was designated "jetty alignment 1, length 1" (Figure 7) with a spacing of 3,500 ft at the jetty tips. The jetties were built in the model from plans furnished by SAW. The same 3-ft-range ocean tide was generated as for base test conditions. Model observations and analyses of surface current photographs showed some conditions that had the potential for introducing problems such as concentration of ebb flows on the outer end of the north jetty; the possibility that a secondary channel would form along and just inside the south jetty; and the impingement of flood currents on the north point, indicating possible difficulty in maintaining the channel through the navigation span. Surface current photographs at maximum ebb and flood are shown in Plates 54 and 55. Storm surge velocities at the Bonner Bridge are shown in Plate 56.

Tests for Jetty Alignment 2

38. The second configuration tested was designated "jetty alignment 2" and it was more nearly parallel to the bar channel that existed in 1975. For each of the alignment 2 plans, the inner end of the north jetty was curved to the north and extended to the bridge in order to provide protection for the northern part of the bridge. Also a 400-ft-wide by 20-ft-deep bar channel across the ocean bar was included for each variation tested (Figures 8, 9, and 10). Jetty spacings of 5,000, 3,500, and 2,500 ft were tested with the

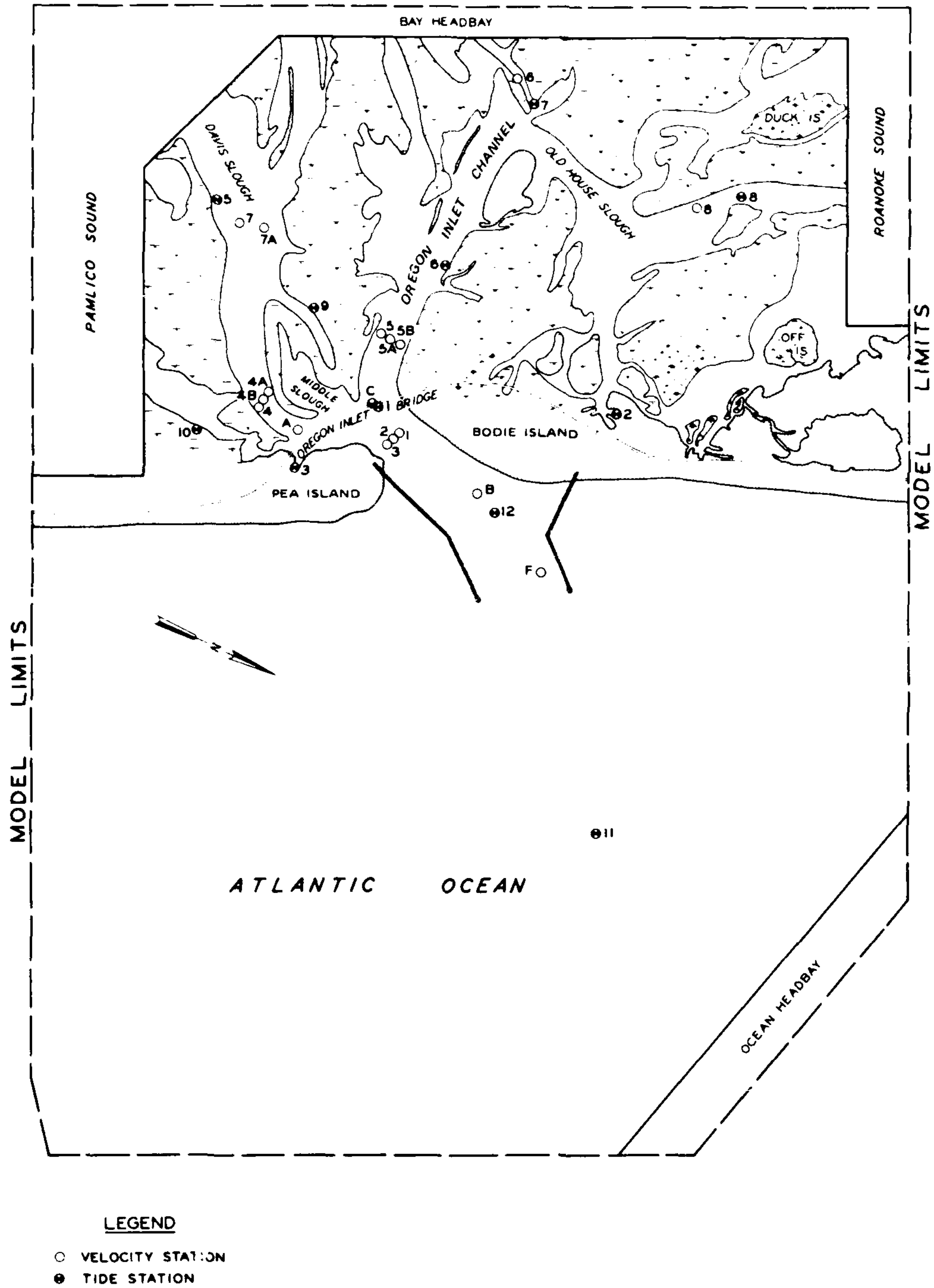

Figure 7. Jetty alignment 1

2,500-ft spacing considered the narrowest possible to examine since that width approaches the existing width of the inlet gorge. Jetty length 1 was 800 ft longer than jetty length 2.

39. Figure 8 shows the layout for jetty alignment 2 with a 5,000-ft spacing. Recorded tides for the 5,000-ft spacing, length 1 jetty system are compared with base test in Plates 57-59. This jetty system caused little change in tides from the base condition. Velocity data for the length 1 jetty system are shown in Plates 60-64, and surface current photographs near maximum ebb and flood are shown in Plates 65 and 66. Photographs showing surface currents with steady flows simulating the peaks of the 12 September 1960 and 7 March 1962 storms are shown in Plates 67 and 68. Storm surge velocities at the Bonner Bridge are shown in Plate 69.

40. The 5,000-ft spacing, length 1 jetty system caused little change in the direction and magnitude of ebb currents in the throat area (sta 1-3) relative to the base test condition. This system produced a more uniform flood current velocity distribution across the flow area. The 5,000-ft spacing gave an indication that a secondary channel might develop along the south jetty (see flow lines just inside south jetty in Plate 65); however, additional dredging could probably aid in realigning the flow to a more central location.

41. Figure 9 shows the jetty locations for alignment 2 with a 3,500-ft spacing. Recorded tides for the length 1 jetty system are compared with base test in Plates 70-72. Current velocities compared with base conditions are shown in Plates 73-77. Surface current photographs near maximum ebb and flood for mean tide conditions are shown in Plates 78 and 79. Photographs showing surface currents for the 12 September 1960 and 7 March 1962 storms are shown in Plates 80 and 81. Storm surge velocities at the Bonner Bridge are shown in Plate 82. The same data for "length 2" jetties are shown in Plates 83-95. There was little change in flow conditions between the 5,000-ft spacing and the 3,500-ft spacing. An indication of the potential for the development of a secondary channel along the south jetty still existed (Plates 78 and 91).

42. Figure 10 shows the jetty locations for alignment 2 with 2,500-ft spacing. For this plan it was necessary to include a 2100-ft-long dogleg on the inner end of the south jetty to tie it into the shoreline. Tidal heights for this length 1 jetty system relative to base test are shown in

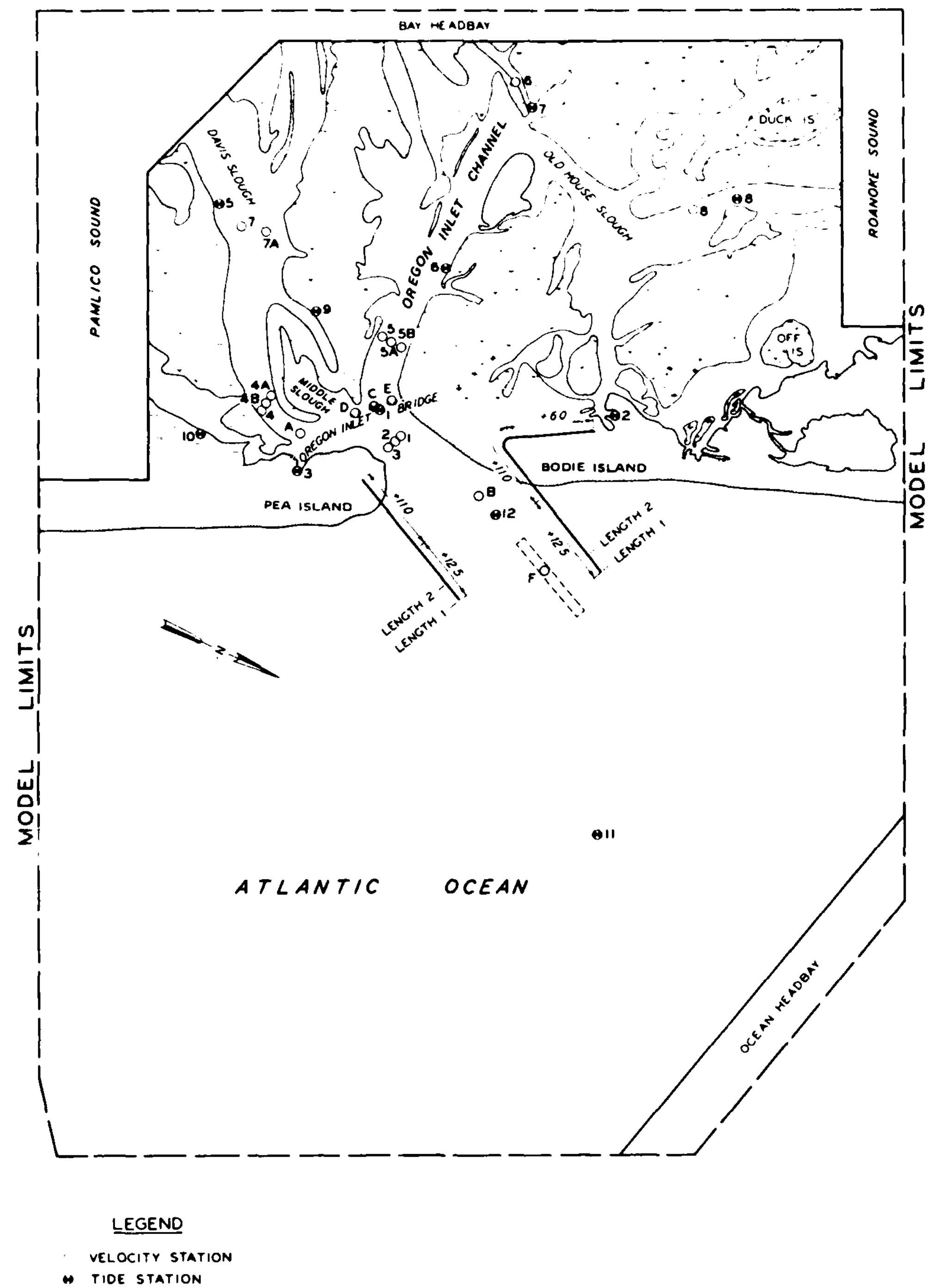

Figure 8. Jetty alignment 2, 5,000-ft spacing

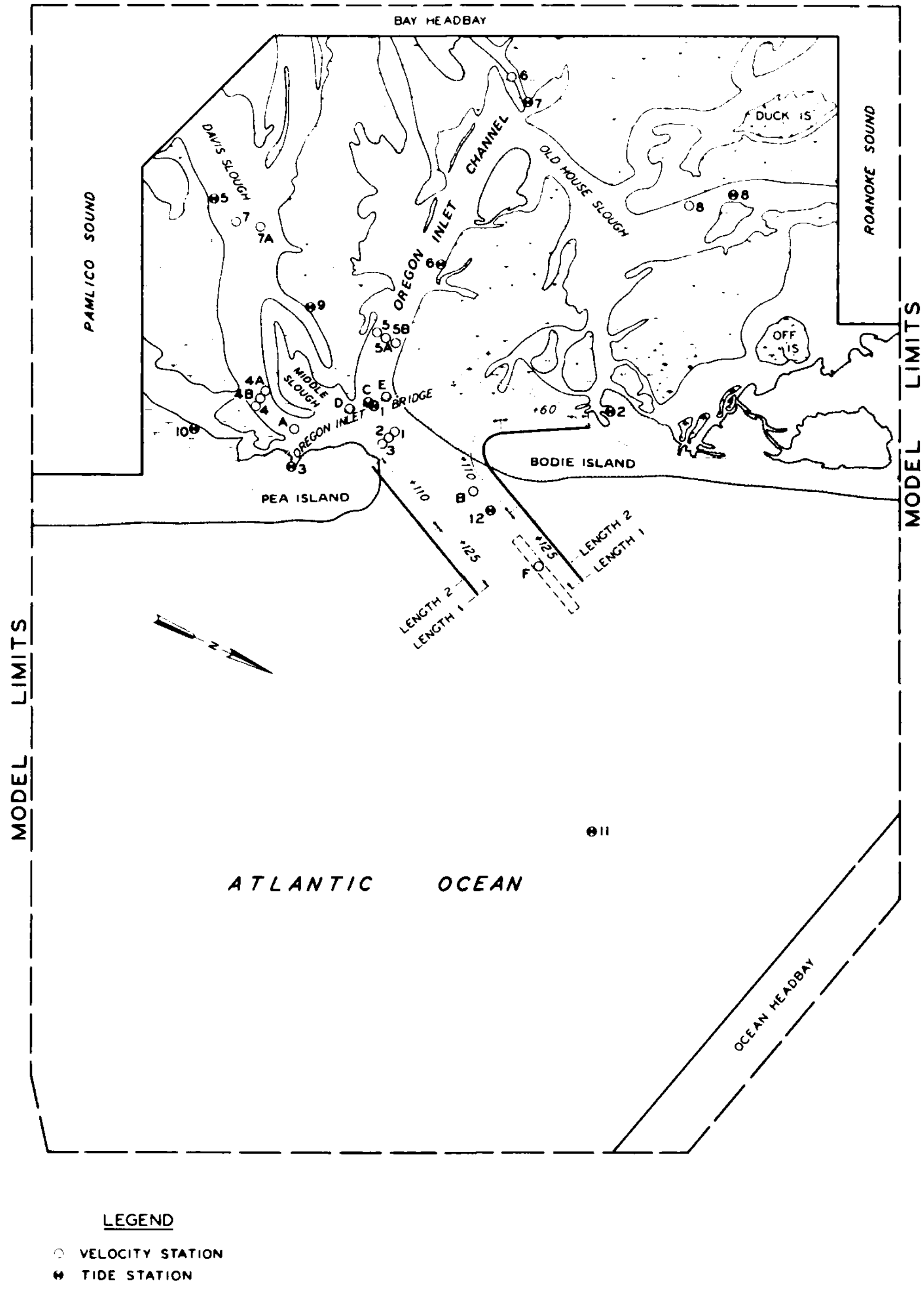

Figure 9. Jetty alignment 2, 3,500-ft spacing

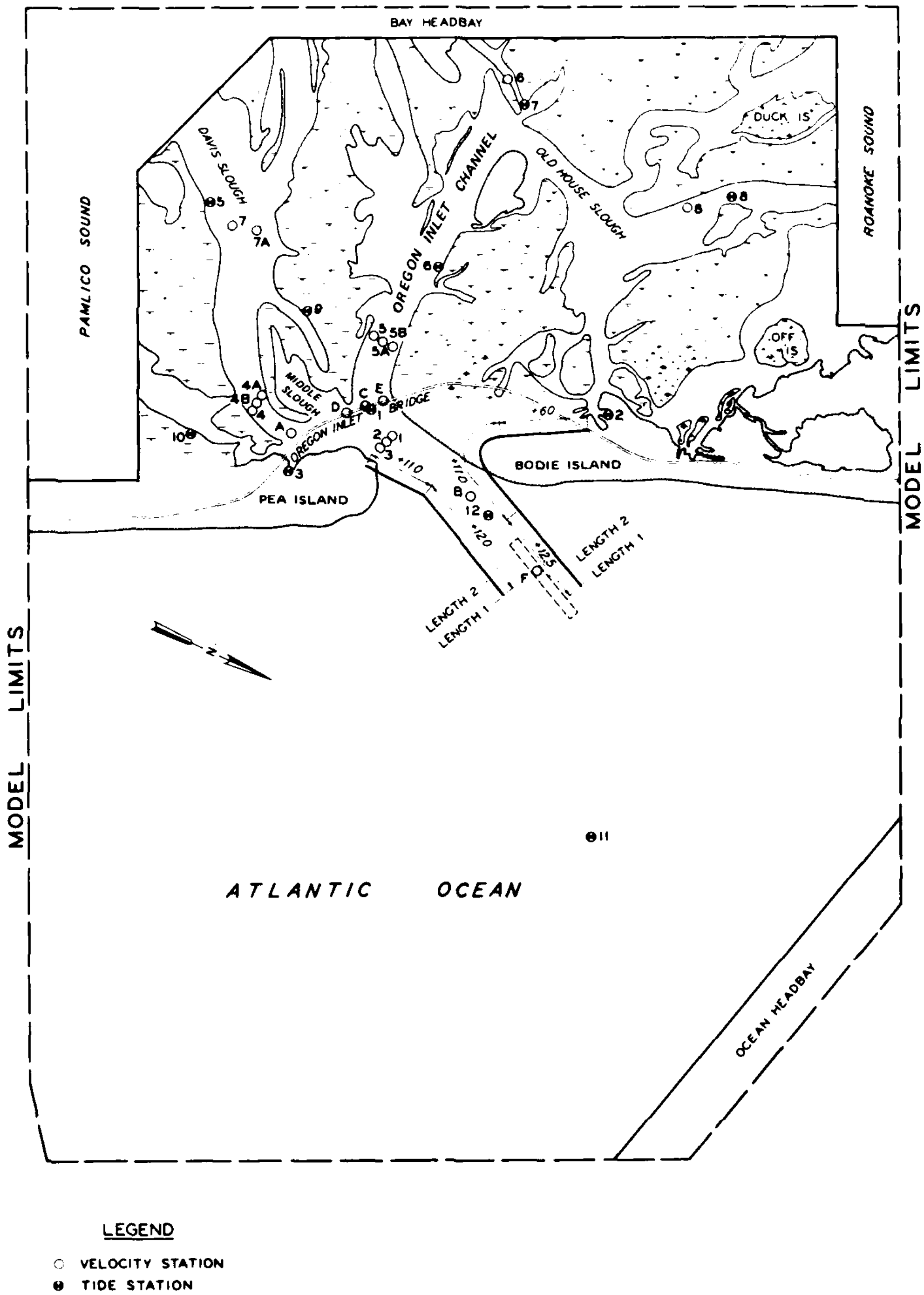

Figure 10. Jetty alignment 2, 2,500-ft spacing

Plates 96-98. Current velocities are compared in Plates 99-103. Photographs that show surface current patterns and velocities near maximum ebb and flood are shown in Plates 104 and 105. Photographs showing surface current patterns and velocities with flows simulating the peaks of storms of 12 September 1960 and 7 March 1962 are shown in Plates 106 and 107 and velocities at the Bonner Bridge are shown in Plate 108. Plates 109-121 show comparable data for jetty length 2.

43. Jetty alignment 2 with 2,500-ft spacing produced good hydraulic conditions with good flow alignment. There was little difference between the length 1 or length 2 jetties; consequently, the length 2 jetty system was chosen for further study (saving 1,600 ft of jetty construction and maintenance). This spacing would also create the greatest changes in hydraulics, so if the 3,500- or 5,000-ft jetty spacing would be required due to other constraints, the testing of the 2,500-ft spacing would show the maximum changes to be expected.

44. The following related hydraulic conditions were produced by the jetty alignment 2, length 2, 2,500-ft spacing system:

- a. Concentration of currents along the presently (1975) existing channel.
- b. Reduction of flood velocities in the deeper areas at sta 1 and 2 thereby reducing rate of sediment transport into sound.
- c. Reduction in probability of formation of a secondary channel along and just inside south jetty.
- d. A measurable decrease in tide range at gage 1 (bridge location) of 0.4 ft (out of 1.8-ft base tide range) and smaller decreases in other bay tide gages of 0.05 to 0.2 ft. These changes were the maximum reductions in tide ranges associated with the three jetty spacings tested. This test can probably be considered an extreme condition, for once a jetty system is constructed, the jetty channel will naturally deepen and provide greater admittance to tidal flow. This will be examined in later tests.
- e. A reduction of velocities at the Bonner Bridge for the ebb and flood storm surges was noted.

45. In all the tests, including the base test and plan tests, ebb flow through Davis Slough impacted on the south shoulder of Oregon Inlet. Historically, erosion has been noted at this location, so to prevent this problem and prevent possible cutting through the barrier island behind the south jetty, rubble revetment would probably be required along the shoulder.

Alignment 2 with Dredged Channels and Landward Extension of North Jetty

46. Jetty alignment 2, length 2, with a 2,500-ft spacing (which also had a 400- by 20-ft channel across the ocean bar) was selected for further testing as it probably would be the plan to produce the greatest changes of the possible plans examined and thus show the maximum limits of hydraulic change. It was noted from the surface current patterns during storm surge tests that high flow occurred between the curved section of the north jetty and the bridge. In order to reduce this flow, which could possibly scour along the north jetty, an extension of the main north jetty trunk 3,500 ft bayward to its intersection with the bridge was made. The elevation of this extension was set at +3.5 ft NGVD, which would permit some flow over it at high water levels so as to reduce the possibility of flow concentrations at other locations along the bridge. This was designated Plan 2A. A 100-ft-wide by 14-ft-deep navigation channel was then dredged at the Bonner Bridge. This was designated Plan 2B, and the addition of a 6-ft depth of bottom protection (rock) along the bridge was designated Plan 2C. Tidal heights and current velocities are compared for these conditions in Plates 122-129. Tidal heights show little change between the three test conditions (Plates 122-124). Velocities (see Figure 10 for location) are shown in Plates 125-129. The only current stations with notable changes were on the north side of the channel. Sta 1, 2, C, and E had changes mainly associated with ebb flow. Bottom protection decreased ebb currents at sta 1, shifting them to sta 2 where an increase in ebb flow was noted. Sta C and E at the bridge in Oregon Inlet channel indicated increases on ebb; therefore the bottom protection shifted ebb currents toward the channel center line.

47. Storm surge velocities for the three above-discussed conditions (Plans 2A, 2B, and 2C) are compared with the original base condition in Plates 130-132. Ebb surge velocities for the three conditions showed little change when compared with the original base test. The slight reduction in these velocities from the base is due to the slight constraining effect of the jetties. Changes in the flood surge velocities at the bridge were minor for the Plan 2A condition and were slightly increased when the bridge channel was dredged (Plan 2B) or was dredged and bottom protection added (Plan 2C).

Tidal Exchange

48. As shown in Plates 109-111, the tidal range at and bayward of the bridge decreased by as much as about 0.4 ft for the Plan 2, 2,500-ft jetty spacing compared with the base condition. A slight decrease in velocities was observed at sta 1, 2, and 3 in the inlet gorge (Plates 112 and 113). Integrating the ebb and flood flows for the normal tidal conditions, a volume reduction of 9.4 and 14.8 percent was determined for ebb and flood flows, respectively. Table 3 shows the flow volumes through the three bay channels as determined from integration of the detailed velocity measurements taken along Bonner Bridge. The most notable observation was the desirable increase of percentage of flood flow in Oregon Inlet channel through the navigation channel under the bridge. The percentage reductions in total ebb and flood flows past the bridge were almost identical with those determined at the velocity range across the inlet throat.

49. The above flow volumes were determined based on the existing (1975) bathymetry plus a 20-ft-deep by 400-ft-wide navigation channel through the ocean bar. It is believed that there will be increased cross-sectional area in the entrance area once the jetties are constructed, as littoral sediments would be excluded and the jetties would aid in flow concentration. In an analysis by SAW, based on maintaining the flow conveyance now existing at the gorge throughout the length of the jettied channel, an assumed scour channel was developed. The scour channel then was installed in the model and model measurements were made. Tests A and AL were run for the scoured condition with Test AL having an extended south jetty. The south jetty was extended 800 ft for test AL to place the tip in deeper water which would reduce the possibility of sediment influx from the shallow shoal region occupied by the shorter jetty tip. Tidal elevations were similar to base conditions (Plates 133-137) indicating that the flow volumes were similar to the base condition and that even a minimum jetty spacing of 2,500 ft should not significantly change the inlet's tidal prism. Plates 138-141 show peak ebb and flood flow surface current patterns for Tests A and AL; a more uniform velocity distribution exists between the jetties for the scoured channel than for the nonscoured channel shown in Plates 117 and 118.

Storm Surge Tests

50. Data from the previously mentioned storm surge tests (i.e. base test and the plan alignment 2, length 2, 2,500-ft spacing) are discussed in further detail in this section and compared with surge test data for the scoured entrance channel. Data collected included velocities, water-surface elevations, detailed velocities along the Bonner Bridge, and surface current photographs. Data for base, Plan 2 (alignment 2, length 2), and Plan 2 with scour channel (Test A) are shown in the following locations, respectively: surface currents--Plates 52 and 53, 119 and 120, 143 and 144; water-surface elevations--Table 4; current velocities--Table 5; detailed velocities along the bridge--Plates 121 and 142 (base data on both plates).

51. During the flood surge (simulating 7 March 1962 or Ash Wednesday storm) water-surface elevations in the bay were reduced by amounts ranging from 0.8 to 1.5 ft (3.6 ft between the jetties) with the Plan 2 jetties in place; however, with the scoured channel configuration, changes from the base were less with reductions ranging from 0.0 to 0.6 ft (3.1 ft between the jetties) (Table 4). Velocity changes are shown in Table 5 and Plates 121 and 142. Flood velocities at the Bonner Bridge were reduced at the north end and were similar to the base for the regular Plan 2 condition (Plate 121). With the scoured channel, Plan 2, there were increases of up to 8 fps but most were within 3 fps. Velocity increases at the end of the jetties and between the jetties were large due to the confining effect of the jetties.

52. The 7.3-ft NGVD ebb surge (simulating surge due to the storm of 12 September 1960 or Hurricane Donna) in the bay for base conditions was increased by amounts ranging from 0.2 to 1.1 ft (Table 4) for the selected Plan 2 jetty condition. When the test was repeated with the jetties and a scour channel, the increases were reduced to amounts ranging from 0.1 to 0.3 ft over the base condition (there were actually water-level reductions of 1.2 and 0.5 ft between the jetties and at the bridge navigation span). Velocities south of the navigation span on Bonner Bridge for the selected Plan 2 condition were reduced by 1 to 2 fps when compared with the base. With the scour channel installed, velocity increases up to 6 fps were observed over the base, with most increases south of the navigation span less then 2 fps.

53. Based on the above, the jetties would not significantly affect existing flooding potential near Oregon Inlet, nor increase the potential

for storm breaches of the barrier islands north and south of the inlet. If the scour channel forms in the prototype as modeled, protection to the bridge will probably be necessitated to prevent excessive scour near the bridge for large storm surges.

Flows Through Bonner Bridge

Introduction

54. As noted in the previous sections, there is a potential for increased velocities through the region of the Bonner Bridge during a storm surge. Figure 11 shows the bridge in the model. The bridge has experienced foundation problems since its construction (without being exposed to significant storm conditions) and it is highly important to safeguard it. In 1965, a deep scour hole estimated to be 60 ft deep was found near the navigation span. Since the piles in the bents of the navigation span reach only to a depth of 60 to 70 ft below mlw, riprap mats were placed around the bents. In 1978, a portion of the bridge in Davis Slough began to subside. Some of the piles were completely exposed in this region (i.e., where piles only penetrate to depths of 25 to 39 ft below mlw). Riprap protection, therefore, was placed around each of the bents in Davis Slough.

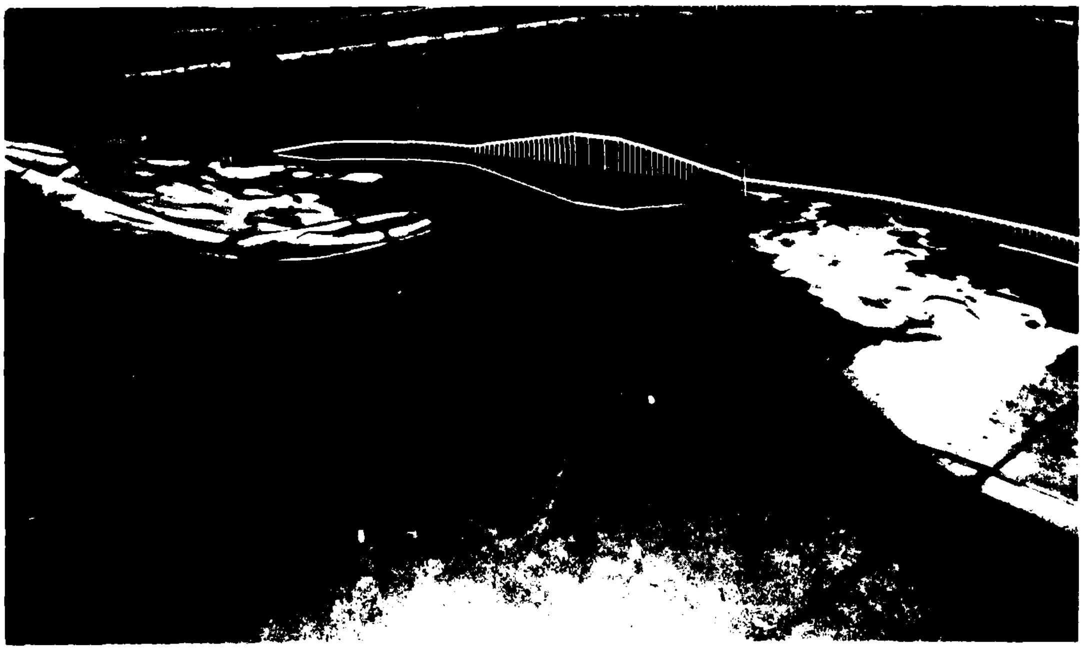

Figure 11. Bonner Bridge in model

55. As shown in Figure 10, the Plan 2 north jetty was extended landward and curved northward to protect the north portion of the bridge. This was found to be necessary when testing the Plan 1 (Figure 7) jetty configuration. Bottom protection for the bridge would begin where the Plan 2 north jetty intersects the bridge and would extend to the southern end. It was necessary to determine the effects of bottom protection on flow conditions for both normal and storm-generated flow conditions. The use of sills placed directly beneath the bridge in Davis and Middle Sloughs for the purpose of diverting flow through the Oregon Inlet channel also was examined. Flow diversion through Oregon Inlet channel would increase velocities in the channel and thereby tend to further reduce shoaling of the navigation channel.

56. Tests of bridge bottom protection and flow diversion sills were conducted before the emergency bridge repairs of 1978, so that the model did not reproduce the bottom protection actually placed at that time. The difference between the actually installed protection and that used in the model was minor and should be of no consequence to the test results.

57. Model test conditions simulated a 3.5-ft-thick by 100-ft-wide riprap mat under the entire bridge except for a 1,200-ft gap centered on the navigation span. The gap had natural depths of the authorized navigation channel. Some testing involved deepening the navigation gap to simulate scour to depths of -30, -35, and -40 ft NGVD. The sills installed for some tests were placed on top of the bridge bottom protection in Davis and Middle Sloughs with crest elevations of -10 ft NGVD, reducing the cross-sectional area of each slough by about 50 percent. Locations of these sills are shown in Figure 12.

58. Originally, a test series was planned and each test numbered; but as tests were carried out and results noted, some testing was eliminated. Therefore Table 6, showing the various tests run and the test conditions, does not have consecutive numbering. Table 6 shows that the first three tests (1, 2, and 7) have no jetties and add bottom protection, then sills, respectively. Tests 12, 13, and 18 have jetties and add bottom protection, then sills, respectively. Tests 20, 21, 22, and 24 examine navigation channels of various depths to try to determine the extent of scour. Test 26 involved an extended fill on the south end of the north bank along the bridge rather than the sills. Also shown in Table 6 are the types of data collected for each test. Plates 145-182 contain surface current photographs and storm

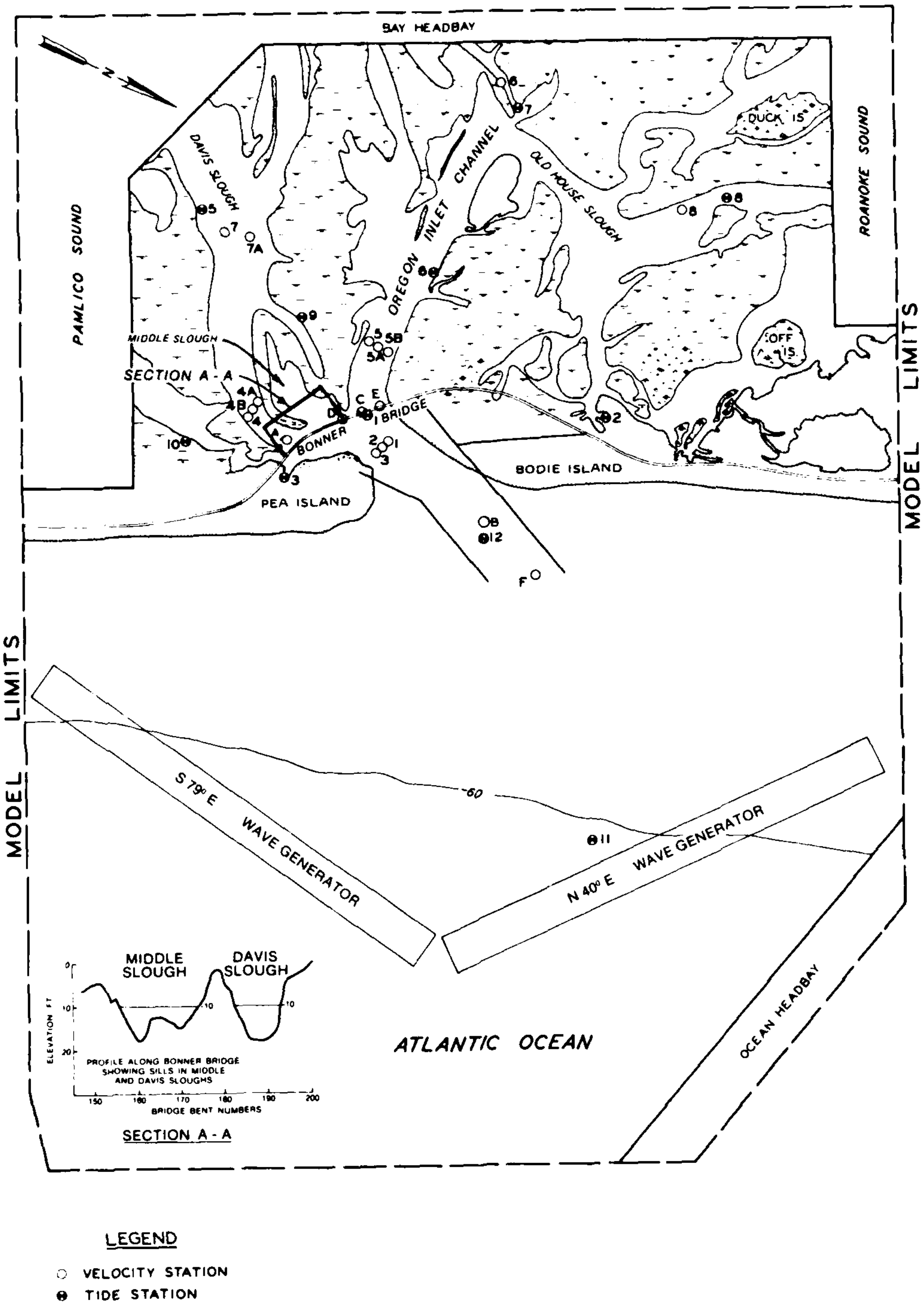

Figure 12. Location of sills along Bonner Bridge

surge velocity plots of each test condition (except Tests 1 and 12, which are base conditions without and with the jetty, respectively, and whose surface current photographs and storm surge velocity plots are seen in Plates 50-53 and 104-107, respectively). Tidal height and velocity data comparisons are made between Tests 1 and 12 (Plates 183-195), Tests 2 and 13 (Plates 196-210), Tests 18 and 26 (Plates 211-223), Tests 20 and 21 (Plates 224-245), and Tests 22 and 24 (Plates 246-266).

Tidal velocities and elevations

59. Tidal elevation changes between Tests 1 and 12 showed decreases in range up to 0.5 ft (Plates 183-187) with most of the change occurring near high water. Velocities in Plates 188-195 were taken at various locations along the bridge piers (see Figures 12 and 13 for locations) for the base condition (Test 1) and the selected plan (Test 12) with the navigation channel configuration. There are slight reductions of up to 1 fps in velocity for the selected plan at most locations when compared with the base condition. There was also a slight velocity phase shift, with Test 12 velocities generally about one time-step (0.4 hr) later than those for Test 1.

60. Comparing Test 2 with Test 13 (in which bottom protection as described previously has been added but conditions are otherwise similar to Tests 1 and 12, respectively), there are similar changes at given locations. Tidal heights (Plates 196-199) do not indicate significant changes between Tests 2 and 13, but the velocity stations at the bridge (Plates 200-205) show up to 1-fps decreases in maximum ebb and flood velocities for Test 13. The velocity phase shift, however, was much less pronounced. Plates 206-210 show velocity comparisons between Tests 2 and 13 at other stations in the entrance channel and bay. The increase in velocities at sta F (up to 3 fps on flood flow) for Test 13 relative to those for Test 2 reflects the difference resulting from channelization of the flow by the jetties (i.e. concentrating flow at this station). This is also seen at sta 1, 3, and B. Therefore if bottom protection were installed before construction of the jetties, then one would expect tide and velocity changes as noted between Tests 2 and 13.

61. Tide elevations and velocities are compared for Tests 18 and 26 in Plates 211-213 and 214-223, respectively. As shown in Table 6, both these tests have jetties, bottom protection, and the existing navigation gap. The difference between the two tests was that sills were in place for Test 18 and were removed for Test 26. Tidal elevations (Plates 211-213) show no

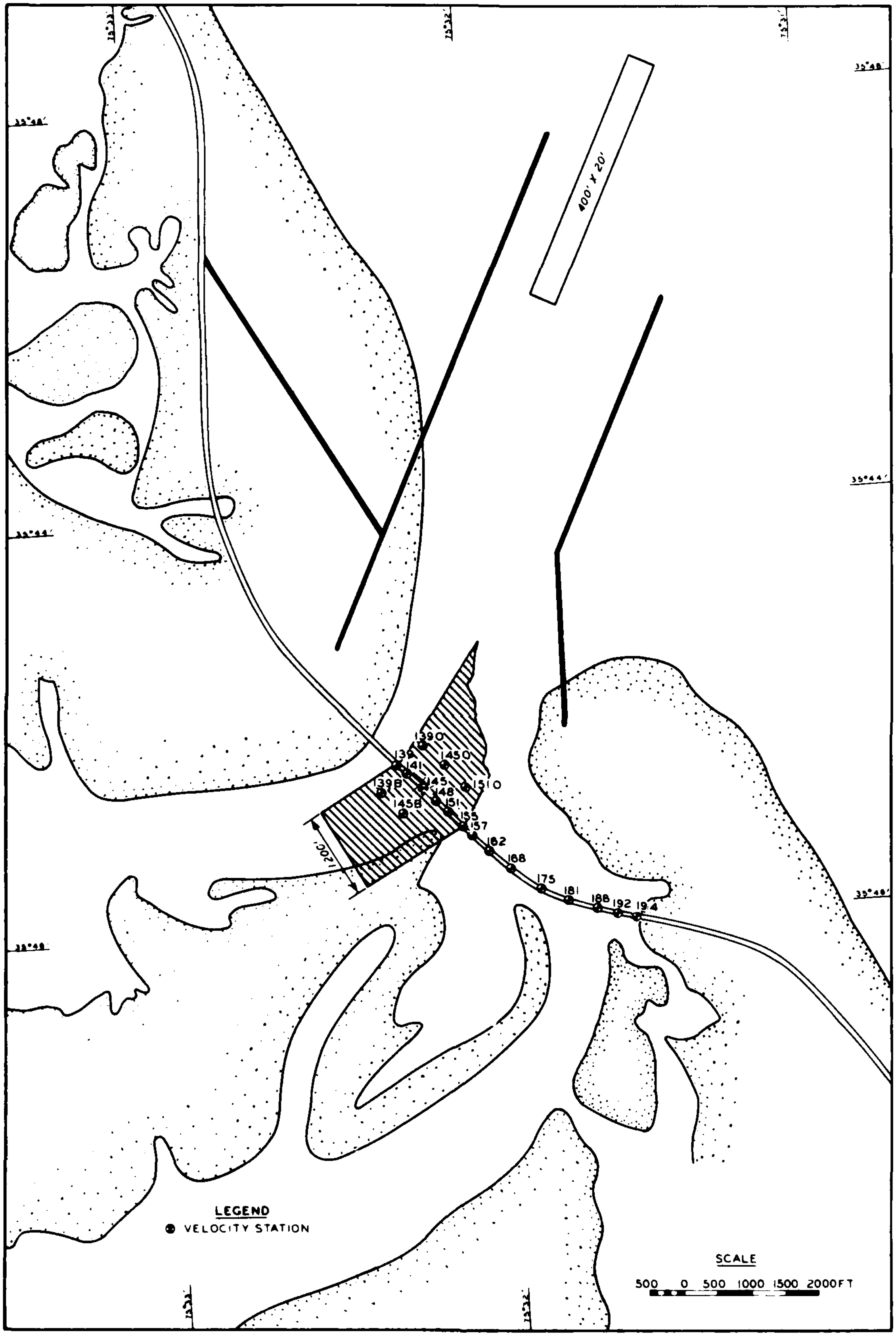

Figure 13. Location of velocity stations and dredging at Bonner Bridge

significant differences. Plate 214 shows that the sills reduced flow at sta A in Davis Slough. Plate 215 shows the shift in ebb velocities from the south side (sta 3) to the north side of the main channel (sta 1), indicating more flow through the existing navigation gap and less through Davis Slough with the sills in place. Flood flows decrease slightly for both sta 1 and 3 with the sills in place. Sta 2, centered between sta 1 and 3, showed little change (Plate 216). Sta 4B (Plate 217) in Davis Slough showed small velocity decreases. Among the stations at and near the bridge (Plates 218-223), sta 139 showed the greatest change in velocities. Sta 139 ocean (see Figure 13 for location) showed increased ebb velocities (up to about 2 fps) with the sills in place and sta 139B showed increased flood velocities (up to about 2 fps) with the sills installed. Velocities at sta 145 and 148 indicated reductions in ebb velocities. The other velocity stations at the bridge showed only minor changes. It is difficult to compare absolute velocity magnitudes to form a conclusion since, as the discussion in the next paragraph indicates, the flow volume, or tidal prism, was reduced for the sill condition (Test 18). As shown in Table 7 though, the percent of ebb and flood flow through Oregon Inlet channel was increased from 33 percent of the ebb and flood flow (Test 26) with no sills to 46.7 and 48.9 percent of the total ebb and flood flow volume for the condition with sills (Test 18). Therefore, with all other conditions the same for the jettied inlet, sills did produce a shift of flow toward the navigation gap region.

Flow volume

62. Table 7 shows the flow volumes calculated for the major channels at the bridge using the velocity station shown in Figure 13. Table 7 shows that as each test element was added (Test 12 to Test 13 to Test 18), the percent of flow increased through Oregon Inlet Channel and decreased through Davis Slough. Middle Slough showed slight decreases in flood flow and increases in ebb flow. Therefore it was apparent that an increased percentage of flow through the Oregon Inlet channel could be obtained with the addition of sills and the bottom protection, though a reduction in total volume through the gorge (as shown in Table 7) would occur.

Storm surges

63. Storm surge velocities through the bridge for the Test 12, 13, and 18 conditions are shown in Plates 153, 160, and 167, respectively. Comparison of the flood flow surge with the base condition at the top of each

plate indicates a gradual increase in velocities as the jetties, then the bottom protection, and finally the sills are added. The increase takes place over the southern half of the bridge (spans 160-200). Maximum increases are on the order of 2 fps (i.e., from 7 and 8 fps to 9 and 10 fps). Changes in velocities for the ebb surge conditions between Tests 12, 13, and 18 were slight.

Channel enlargement at bridge

64. Tests 20, 21, 22, and 24 were conducted with various depths in the area adjacent to the navigation span dredged as shown in Figure 13 in an attempt to determine the probable depth of scour. For Test 20, the region shown in Figure 13 was dredged to -40 ft; for Test 21, to -35 ft; for Test 22, to -30 ft; and for Test 24, to -20 ft. For each of these tests, the jetties, bottom protection, and sills were in place. Plates 224-245 compare Tests 20 and 21 tidal heights and current velocities, and Plates 246-266 compare results for Tests 22 and 24.

65. Elevation and current variations between Test 20 (-40 ft) and Test 21 (-35 ft) were minimal, with the surface velocities at sta 145 ocean (ebb) and 148 (ebb and flood) (see Figure 13 for location) showing increases for the 40-ft depth. Differences between Tests 22 and 24 (with 30-ft and 20-ft dredged depth, respectively) were more evident with slight decreases in Test 24 flood velocities noted at sta 1, 2, and B and increases (usually at the surface and of short duration) for Test 24 noted at sta 139B, 139 ocean, 141, and 145B of up to 2 fps.

66. In order to determine the maximum depth of scour through the navigation span, it was assumed that the flow volume through the Oregon Inlet channel should approach the base conditions (no jetties). However, as shown in Table 7 (showing flow volumes), data in the flood and ebb tidal prism increased with each increase in depth except for one flood flow case. Therefore the tidal exchange for the different test conditions did not give any indication of the ultimate depth of scour in the gap. Table 8 shows maximum bottom flood and ebb velocities for the various stations in the dredged areas. These values were then averaged for each test condition and the trend of bottom velocities can be seen. For flood velocities, once the 35-ft depth is reached the average bottom velocity levels off to 1.3 fps. For ebb velocities, the reduction of velocity with increased depth occurred at the 30-ft dredged depth.

Sills without jetties

67. The only remaining bottom protection test not discussed was Test 7, in which the nonjettied condition had both bottom protection and sills. The only data collected for this case were the surface current photographs shown in Plates 149-152 for tide and storm surge conditions. Comparison of current patterns with Test 2, the nonjettied condition with bottom protection and no sills, shows little change in flow pattern.

Staged Jetty Construction Tests

68. Construction of the selected jetty plan (alignment 2, length 2, with 2,500-ft spacing) was simulated in incremental stages for various sequences in order to determine if a particular sequence would minimize velocities at the seaward end of the jetties (which would be equivalent to minimizing scour). Scour during construction is undesirable since more construction material (i.e. stone) would be required to fill the scoured region.

69. Construction was simulated by installation of one-quarter length segments. These were determined by dividing the distance from the jetty's intersection with the shoreline to its oceanward tip into four equal parts. The sequences of construction tested were:

Sequence 1: Build both jetties at the same time.

Sequence 2: Build one-half of the south jetty prior to extending the north jetty beyond the existing shoreline.

Sequence 3: Complete the south jetty prior to extending the north jetty beyond the existing shoreline.

70. Table 9 shows the elements of each sequence. Tidal elevations were taken at gages 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, and 12. Currents were measured at sta 1, 2, 3, 4B, 5B, A, B, D, E, F, and Bridge. Photographs of surface currents near the jetties were obtained for maximum ebb and flood current conditions.

71. Tidal heights (Plates 267-284) for the various sequence conditions showed only slight changes between one another. In each plate, the tidal heights for various sequences are compared with the fully constructed jetty system (designated as north 4/4, south 4/4). The most notable change is at gage 12, located offshore between the jetties, which responds more like the bay tides as jetty construction progresses.

72. Current velocities during the sequence 2 construction are compared with those for the fully constructed jetties in Plates 285-314. Sta F (between the jetties near the outer end of the north jetties) shows the greatest differences. As the jetties increase in length, velocities are increased at this location. At the bay stations, velocities generally show a slight decrease as the jetties increase in length. Velocity changes on the whole are slight when compared with the fully constructed jetties.

73. Table 10 shows the maximum velocities that occurred at velocity stations in the entrance channel and in the bay for the various stages of the three different construction sequences. The table also shows the averages of the maximums over the entire construction sequence. Examination of the averages shows that the only differences greater than 0.3 fps between the three sequences were at sta D during ebb flow where sequence 1 provided the smallest average maximum velocity.

74. From the surface current photographs (Plates 315-340) taken during staged construction, flood current magnitudes were measured at the seaward end of the north and south jetties and are tabulated below for the various construction stages. Flood velocities for base conditions at the same locations also are tabulated for comparison.

Sequence	Stage of Construction Completed		Flood Velocity at End of Jetty During Construction Stage, fps			
			South Jetty		North Jetty	
	South Jetty	North Jetty	Staged Construction Test	Base* Test	Staged Construction Test	Base* Test
1	1/4	1/4	4.0	2.8	2.5	2.2
	1/2	1/2	3.5	3.0	2.5	1.7
	3/4	3/4	4.5	3.0	2.5	1.1
	4/4	4/4	2.8	0.8	2.8	1.1
2	1/4	0	3.8	2.8	2.5	2.2
	1/2	0	3.5	3.0	2.5	2.2
	3/4	1/4	4.0	3.0	3.3	2.2
	4/4	1/2	3.0	0.8	2.5	1.7
	4/4	3/4	3.5	0.8	3.5	1.1
	4/4	4/4	2.8	0.8	2.8	1.1
3	1/4	0	3.8	2.8	2.5	2.2
	1/2	0	3.5	3.0	2.5	2.2
	3/4	0	4.2	3.0	3.1	2.2

(Continued)

* Velocity measured at point on jetty alignment corresponding to construction stage.

Sequence	Stage of Construction Completed		Flood Velocity at End of Jetty During Construction Stage, fps			
			South Jetty		North Jetty	
	South Jetty	North Jetty	Staged Construction Test	Base Test	Staged Construction Test	Base Test
3	4/4	0	2.5	0.8	3.0	2.2
(Cont'd)	4/4	1/4	2.4	0.8	3.4	2.2
	4/4	1/2	3.0	0.8	2.5	1.7
	4/4	3/4	3.5	0.8	3.5	1.7
	4/4	4/4	2.8	0.8	2.8	1.1

75. Examination of surface current velocities at the end of the south jetty during construction of the three sequences indicated that respective velocities at the 1/4 and 1/2 stages of construction were about the same. With the south jetty at the 3/4 stage, sequence 2 system of construction had a slightly lower velocity (4.0 fps) than sequence 1 (4.5 fps) or 3 (4.2 fps).

76. Velocities at the north jetty tip are minimized by the sequence 1 construction, with sequences 2 and 3 having nearly the same velocities at the jetty tip for given stages of construction.

77. When compared with the base velocities at given locations (see tabulation in paragraph 74), all the flood velocities during staged construction were greater than the base (or existing conditions) so that scour of the shoals would occur as jetty construction proceeds for any one of the sequences.

78. During maximum ebb currents, flow around the jetty tips was not very significant, especially once they were extended past the 1/4 stage of construction and did not change with variation in the construction stage. Current alignment, once the jetties extended out past the 1/4 stage, was usually nearly parallel to the jetty structure. Also, the south side of the south shoal deflected ebb currents away from the south jetty.

79. As a result of the above tests, it was concluded that scour would likely occur during jetty construction at the jetty tips and all three sequences appeared to be equal in terms of the relative scour potential. Also, the flood currents would contribute more significantly to the scour than would the ebb currents.

Wave Attenuation Between the Jetties

80. Tests were run to determine wave attenuation characteristics in

the region between the jetties during storms. This information could be used as an aid in the structural design of the jetties. Wave heights were nondimensionalized by dividing the wave height at a given gage along the structure by the wave height at the head of the jetties. Figure 14 shows the gage locations. The following tabulation shows wave heights with the water level at +8.0 ft above NGVD, and the wave front approaching directly perpendicular to the jetties' alignment as shown in Figure 15.

Wave Gage	Wave Heights Between the Jetties: Wave Height ft (Prototype)	Relative Wave Height
4	13.8	1.00
5	13.4	0.97
6	5.2	0.38
7	5.0	0.36
8	4.5	0.33
9	4.6	0.33
10	4.1	0.30
11	3.3	0.24
12	2.9	0.21
13	1.8	0.13

Jetty Door Test

81. Normally after construction of jetties, sediment will accumulate at the intersection of the shoreline and the jetty to form a fillet region. Model sediment tracer tests (discussed in paragraphs 85 to 99) indicated this also. These fillet shoals would have to be dredged periodically to keep their size to a minimum. Due to wave activity and shallow depths, dredging would be difficult in this area and the dredge would be exposed to wave attack at all times when dredging from the ocean inward. Therefore, the Wilmington District proposed a plan for dredge entry into the fillets from the channel side of the jetties. By starting to dredge behind the shoal areas, most of the dredging problems caused by wave action would be eliminated. Doors were provided to limit the wave exposure of the dredge and prevent currents from introducing sediment into the channel. The channel approaching the jetty doors would be dredged to permit the dredge access to the outer portion of

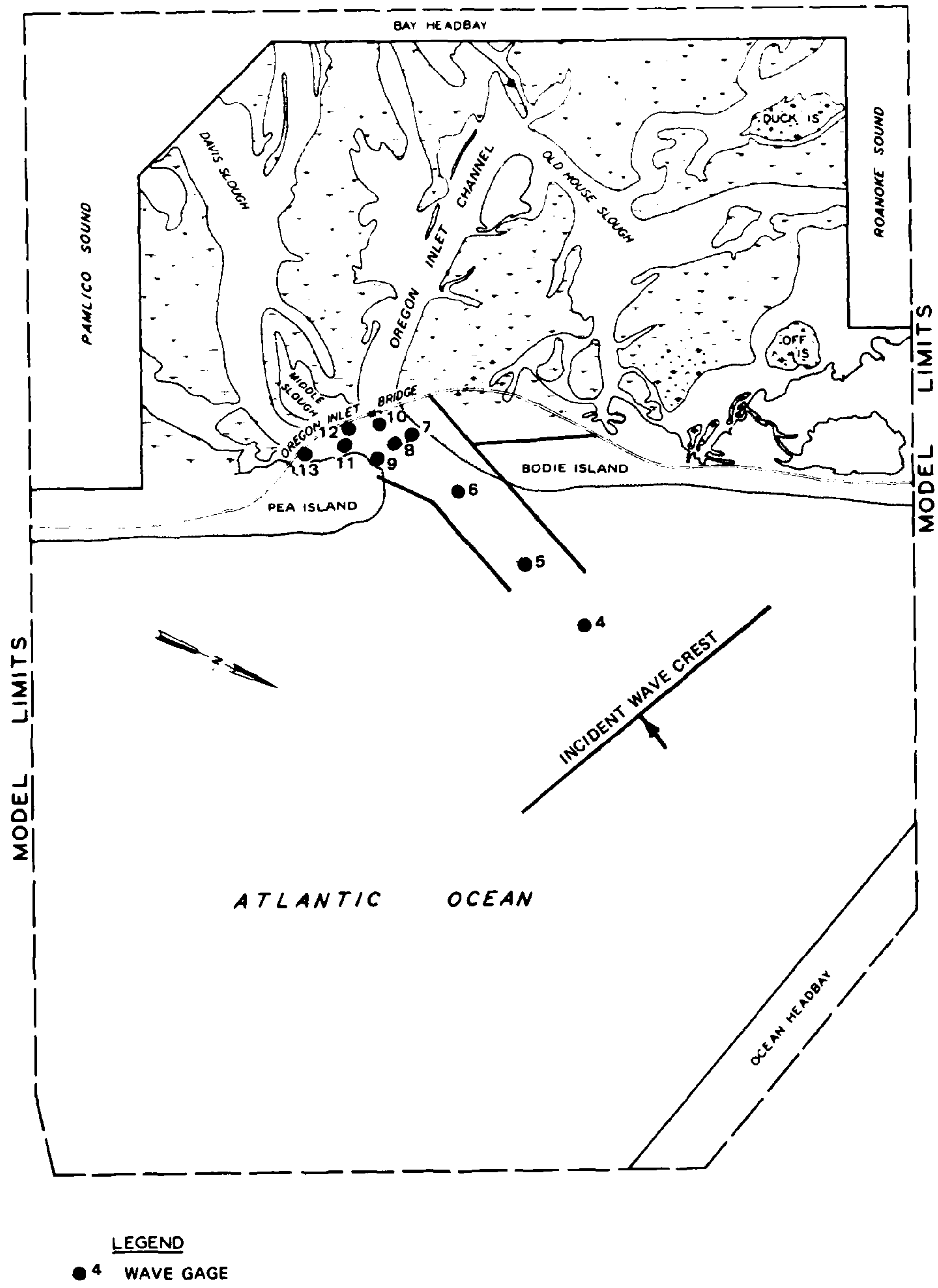

Figure 14. Wave gage locations

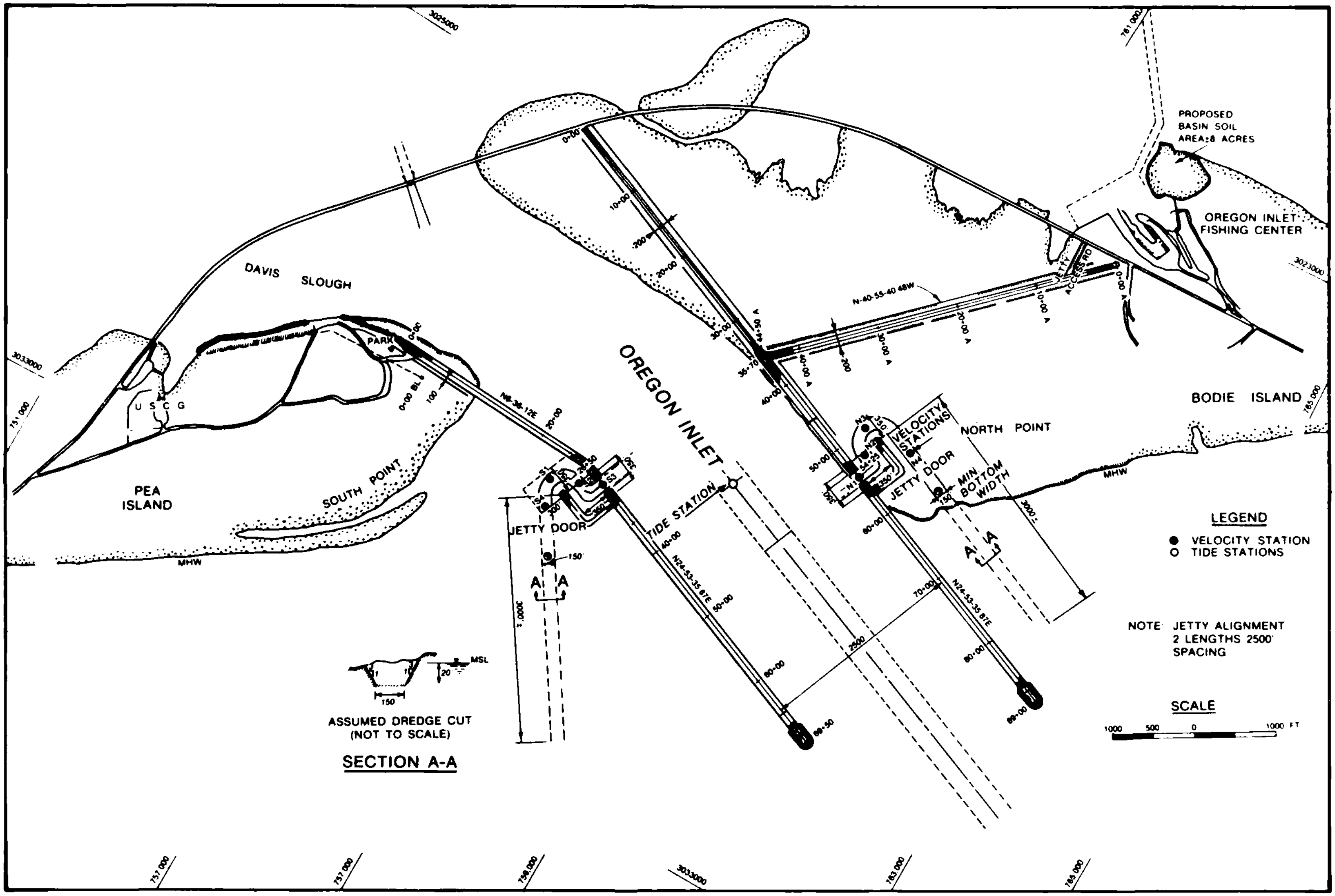

Figure 15. Jetty door locations

the fillet in relatively calm wave conditions.

82. Locations of velocity stations in the dredged channels and location of a tide station between the jetties are shown in Figure 15. Also, velocity measurements through each door section were required for (a) normal tides, (b) spring tides, (c) an ocean to bay water-level differential of 5.0 ft (ocean surge + 6.0 ft NGVD), and (d) a bay to ocean water-level differential of 5.0 ft (bay surge + 6.0 ft NGVD). When velocity measurements were made through one door section, the other door was closed.

83. Upon completion of construction of the desired door openings and the dredged channels in the model, a normal tide (with a range from a high of +1.8 ft NGVD to a low of -1.2 ft NGVD) and a spring tide (with a range of +2.7 ft NGVD to -0.9 ft NGVD) were tested and results are presented in Plates 341-346.

84. After the two tide conditions were run for both jetty door openings, the surge conditions were run. The flood condition was run using a +6.0 ft NGVD level for the ocean and a +1.0 ft NGVD level for the bay. Velocity measurements for both jetty door conditions using flood flow are shown in Table 11. For the ebb condition, the ocean level was set at +1.0 ft NGVD and the bay was set at +6.0 ft NGVD. Velocity measurements were taken for both jetty door conditions and results are shown in Table 11.

85. Velocities for the tidal test indicated that ebb velocities were similar for mean and spring tides and were always less than 2 fps. Flood velocities for spring tides peaked as high as 5 fps (sta S-1) but maximums at other stations were about 4 fps. Mean tide conditions usually produced lower flood velocities than the spring tide (except sta N-1). Sta N-1 and S-1 had the maximum velocities during surge conditions, with maximum flood velocities over 8 fps and maximum ebb velocities over 7 fps.

Sediment Tracer Tests

86. Tracer tests were conducted to determine sediment movement patterns for the jetty alignment 2, length 2, with 2,500-ft spacing and 3.5 ft of bottom protection along Bonner Bridge and for existing conditions.

87. The material chosen for the tracer testing was a plastic cube, about 3 mm on a side, with a specific gravity of 1.18. This material (Tenite butyrate plastic) had been successfully used in previous model studies of

Masonboro Inlet, N. C., and Little River, N. C., which had scales identical with those of the Oregon Inlet model.

88. The tracer material was injected into the model at two locations (dependent on wave direction and shown in Figure 16) using an automatic feeder known commercially as the SCR-20 feeder from Vibra Screw, Incorporated. The feeder was equipped with a cone-shaped hopper with a screw shaft through the bottom which was driven by a variable speed motor. As the screw turned, the material was forced through a tube over the injection point. The hopper sat on a vibrator that was turned on and off with the same switch as the screw motor. The vibrator kept material on the screw at all times for a uniform flow of material.

89. The feeder rate was determined by injecting material until a rate was obtained that resulted in no buildup around the injection point. As the material was injected, wave action combined with tidal currents moved the material along the beach.

Test conditions

90. For all tests, a 3-ft tide range was reproduced with a high of 1.8 ft NGVD and a low of -1.2 ft NGVD. There were two wave directions--S79°E and N40°E--both with an 8.5-sec period. Three model conditions were used: two with the jetties, dredged channels, and 3.5-ft bottom protection along Bonner Bridge (Figure 16), and the other with base conditions (May 1975 survey).

91. Tests 1 and 2 were conducted using the S79°E, 2.8-ft, 8.5-sec wave with the tracer material injection point south of the south jetty. The feeder rate for both Tests 1 and 2 was set at 1.07 cu ft/hr (model), equivalent to 214,000 cu yd (prototype)/model hour. A prototype time scale was not determined since these tests were planned to be a qualitative rather than quantitative nature.

92. The only difference between Tests 1 and 2 was that the length of south jetty for Test 2 was increased so that a line joining the jetty heads was perpendicular to each jetty. This was done to determine the effect of jetty length on sediment transport around the tip of the jetty.

93. Test 3 was conducted using a N40°E, 3.4-ft, 8.5-sec wave, with the tracer material injection point north of the north jetty, and the same material feeder rate as Tests 1 and 2. For this test, an additional 4 ft (model) was added to the plunger on the north wave generator to provide additional updrift coverage.

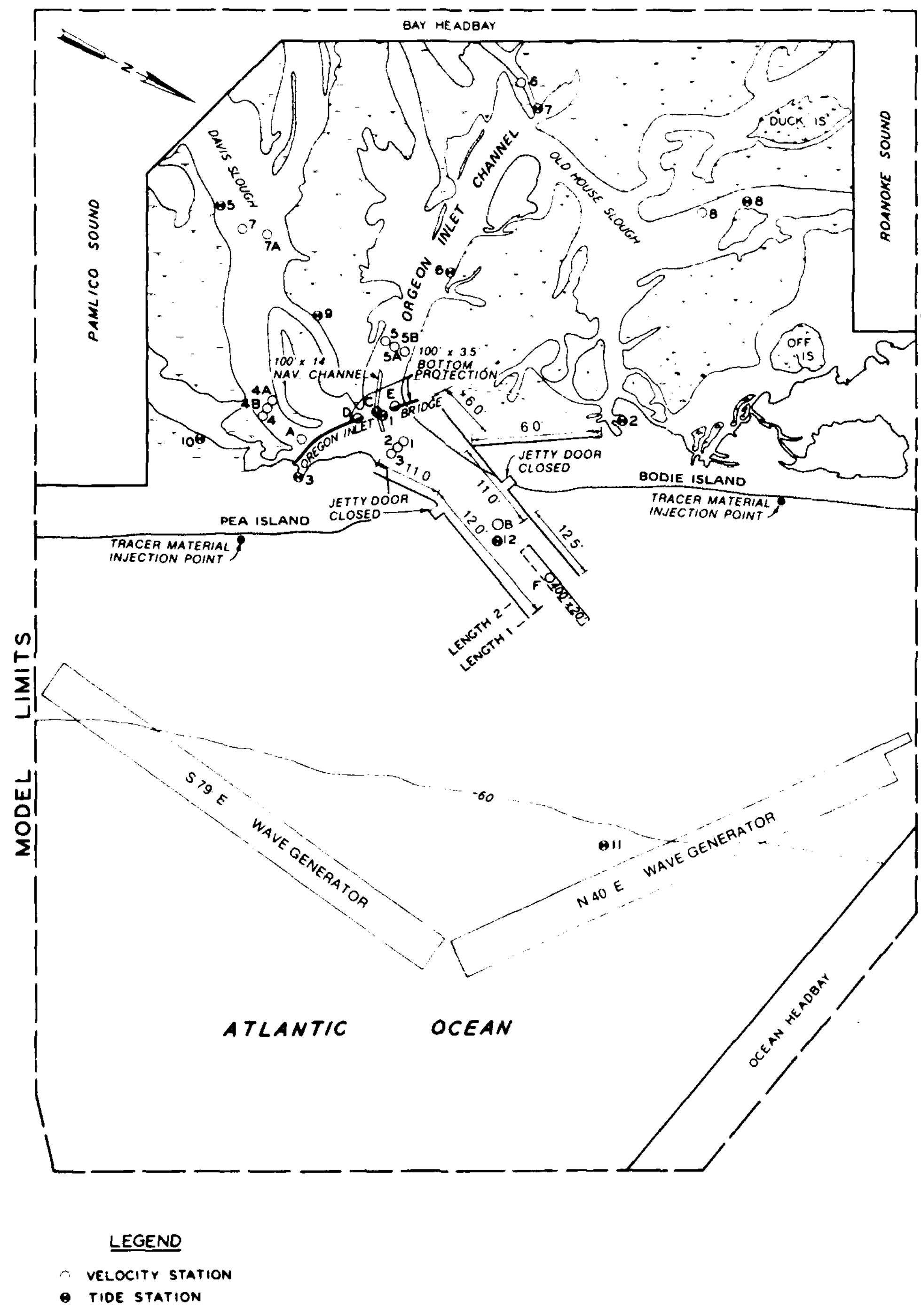

Figure 16. Tracer test testing conditions

94. Test 4 was conducted with the model in the base condition (May 1975 survey). A N40°E, 3.4-ft, 8.5-sec wave and a material injection rate the same as that in the previous test were used. The injection point of material was north of the north jetty. Tests 3 and 4 offer a direct comparison of sediment transport for northerly waves with and without the jetties.

95. Test 5 was conducted with the model in the base condition using a S79°E, 2.8-ft, 8.5-sec wave. Tracer material was injected south of the south jetty at the same rate as previous tests. Tests 1 and 5 offer a comparison of sediment transport for southerly waves with and without the jetties.

Test results

96. Test 1 (Figure 17). After 20 min of model operation (one tidal cycle), a small amount of material was detected around the tip of the south jetty with small deposits on the south side of the jetty. At 30 min (model), deposits inside the jetties were enlarging and movement around the jetty tip was more detectable. During flood flow, there was a slight movement of material up the channel toward the bridge. After 3 hr 10 min (model), the material had built up inside the south jetty and the tip of the fillet outside the jetty extended to the outer end of the jetty. After the material

Figure 17. Tracer Test 1 after 6 hr

reached this point, it started to build up more rapidly on the tip of the south jetty toward the channel. After 4 hr of model operation, the deposits on the channel side of the jetty had built up to the point that almost all of the material swept around the end of the jetty was moved on into the channel on flood flow. At 6 hr (model), the material was collecting mainly around the tip of the jetty; this buildup was on both sides of the jetty tip with a small amount being swept into the navigation channel during the peak of the ebb and flood flows. From these results, it appeared there would be a time when the sediment material would have accreted to such a degree that periodic maintenance dredging would be required in the navigation channel (i.e. from material passing the tip of the jetty).

97. Test 2 (Figure 18). After 2 hr 5 min (model), the first trace of material had moved around the tip of the extended south jetty toward the channel. Considerable buildup was formed in the fillet behind the south jetty. After 4 hr (model), the buildup still continued behind the south jetty with only a small amount reaching the tip of the south jetty and moving toward the channel. After 6 hr (model), the buildup was continuing behind the south jetty and had reached the original length of the south jetty. There

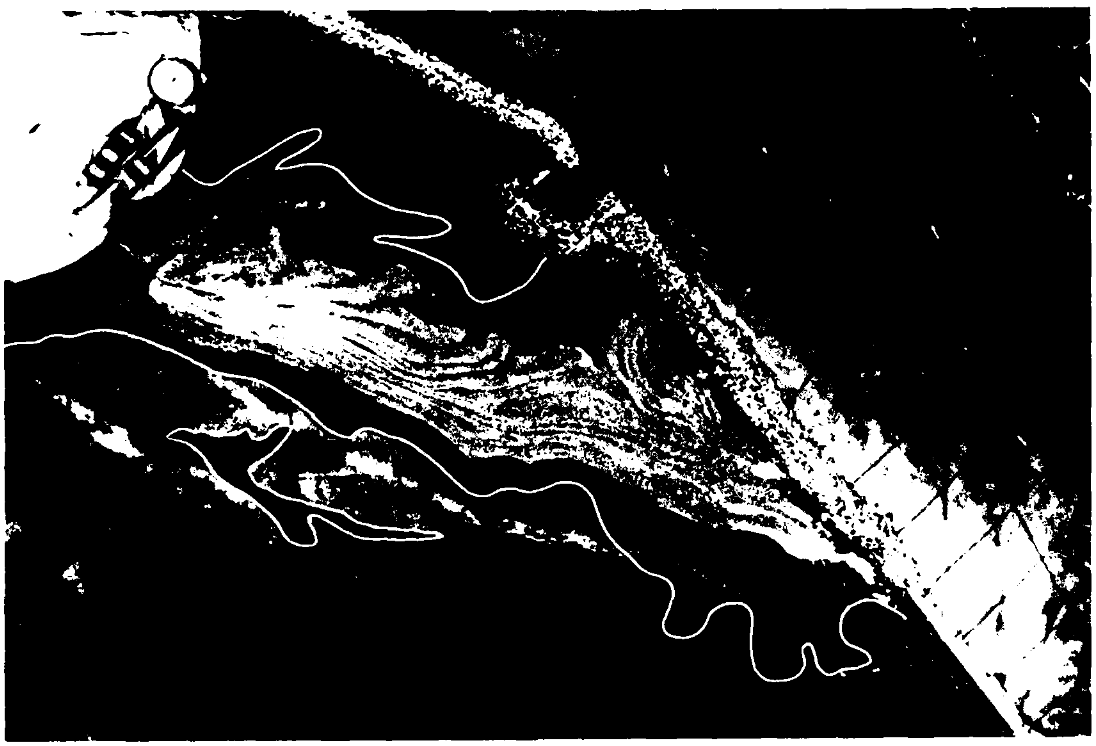

Figure 18. Tracer Test 2 after 6 hr

was still only a very small amount of material reaching the tip of the jetty. Thus with the lengthening of the south jetty, it would take considerable more time for the sediment buildup in the fillet to reach a point where it would start flowing around the tip of the south jetty toward the channel.

98. Test 3 (Figure 19). After 3 hr of operation, the sediment buildup in the fillet had reached the north jetty and the sediment tracer extended perpendicular from about sta 122+00 to the beach. The buildup was in alignment with the wave front. After 6 hr of operation, the fillet had migrated to sta 130+00 on the north jetty and the deposit was much heavier. All of the littoral drift from the north was caught in the fillet behind the north jetty. After a sufficient length of time, this buildup would have reached a point where it would have flowed around the tip of the north jetty toward the channel.

99. Test 4 (Figure 20). After 30 min (model), sediment had collected along the beach on Bodie Island with the flood flow carrying some sediment to the channel. At 1 hr 25 min (model), the sediment extended from along the beach to a little past the 10-ft contour along the channel. The shoal along the beach continued to build up. At 2 hr 54 min (model), the shoal along the beach had a tip protruding seaward parallel to the channel with sediment flowing into the channel on flood flows. At 5 hr 55 min (model), the shoaling material buildup along the beach was heavy, protruding to the 10-ft contour and running parallel with the channel toward the bridge. Comparison of Tests 3 and 4 (Figures 17 and 18) shows that for the time the two tests were run, the jetties kept all the material out of the channel.

100. Test 5 (Figure 21). At 10 min (model), the material flowed around the point of Pea Island into the channel. At 30 min (model), sediment deposits began to collect along the beach side of Pea Island toward the inlet with some deposits collecting along the 10-ft contour of the channel. At 1 hr (model), the sediment was at the same location but was building heavier deposits. At 2 hr 5 min (model), the sediment reached from the beach to the 10-ft contour with a few spots reaching the 20-ft contour in the channel. At 3 hr, the sediment was at the same location but was heavier and extended more toward the 20-ft contour in the channel. With the testing time at 5 hr 20 min, the sediment shoaled at the same location with the buildup becoming heavier. Comparison of Tests 1 and 5 (Figures 17 and 21) indicates that jetties would keep the material out of the channel for a much longer period.

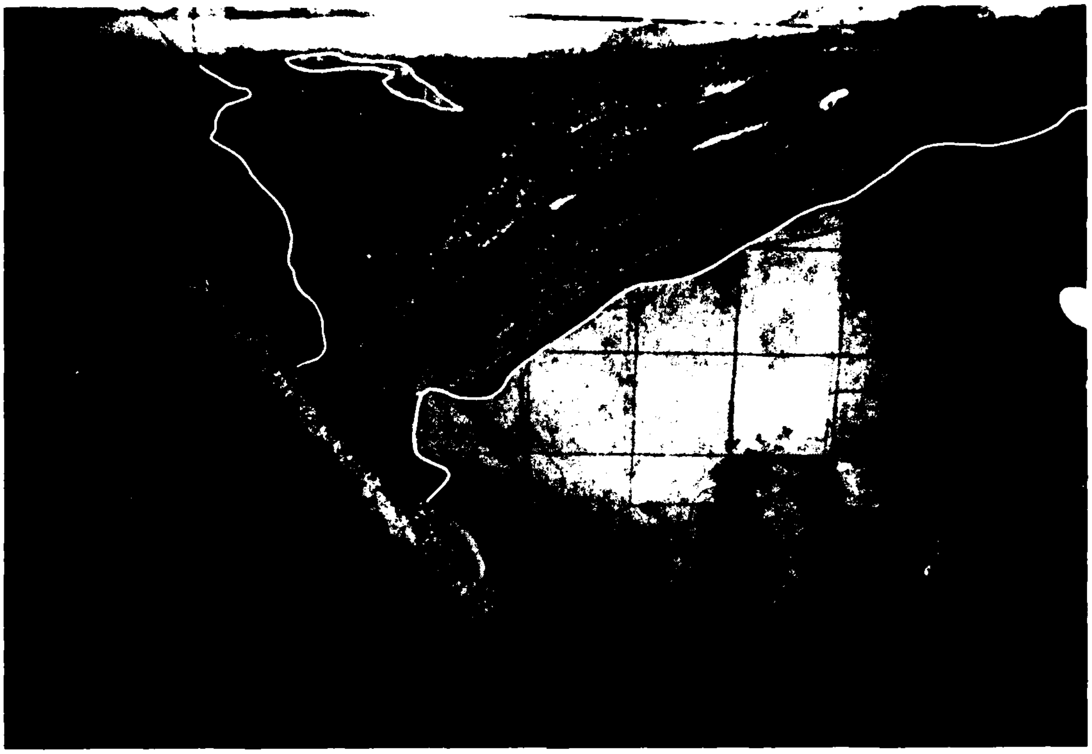

Figure 19. Tracer Test after 6 hr

Figure 20. Tracer Test 4 after 6 hr

Figure 21. Tracer Test 5 after 5 hr 20 min

Also the increased velocity in the channel with the jetties installed would help to minimize channel shoaling, thus reducing dredging requirements.

Movable-Bed Tests

Movable-bed adjustment

101. The validity of tests of proposed improvement plans in a movable-bed model is based on the following premise: if model reproduction of the prototype forces known to affect movement and deposition of sediment (tides, tidal currents, waves, etc.) produces changes in model bed configuration similar to those observed in the prototype under similar conditions, then the effect of a proposed improvement plan on the movement and deposition of sediments will be substantially the same in both model and prototype.

102. Trends and magnitudes of prototype bed movement under existing conditions are determined primarily through detailed comparison of two or more periodic prototype surveys of the area under study. Due to the lack of periodic surveys, aerial photographs for the past several years (12 May 1975 through 10 April 1979) were compared to establish the trends of sediment movement in the inlet area (Plate 347). In general, the verification consisted of initially operating the model with scaled, available prototype data. Based on results of these tests, selected test parameters were varied in subsequent tests until a satisfactory reproduction of the prototype scour and fill was achieved.

Movable-bed material

103. Coal was selected as the movable-bed material for the model and a large quantity was purchased. The screening of the coal was accomplished, using a vibrating screener. A No. 6 mesh, allowing only material 3.35 mm (0.132 in.) and smaller to be passed, was used for the upper screen. The second screen, located directly below the first, retained material 0.42 mm (0.0165 in.) and larger. The size of the coal, therefore, ranged from 3.35 mm to 0.42 mm. Approximately 53 percent of the original coal purchased was retained as usable movable-bed material following the screening process. The median grain diameter of the coal was 1.89 mm as shown in Figure 22.

Sounding system

104. For the movable-bed tests, a rail and cart system was installed to facilitate determination of bottom elevations. The rails were located

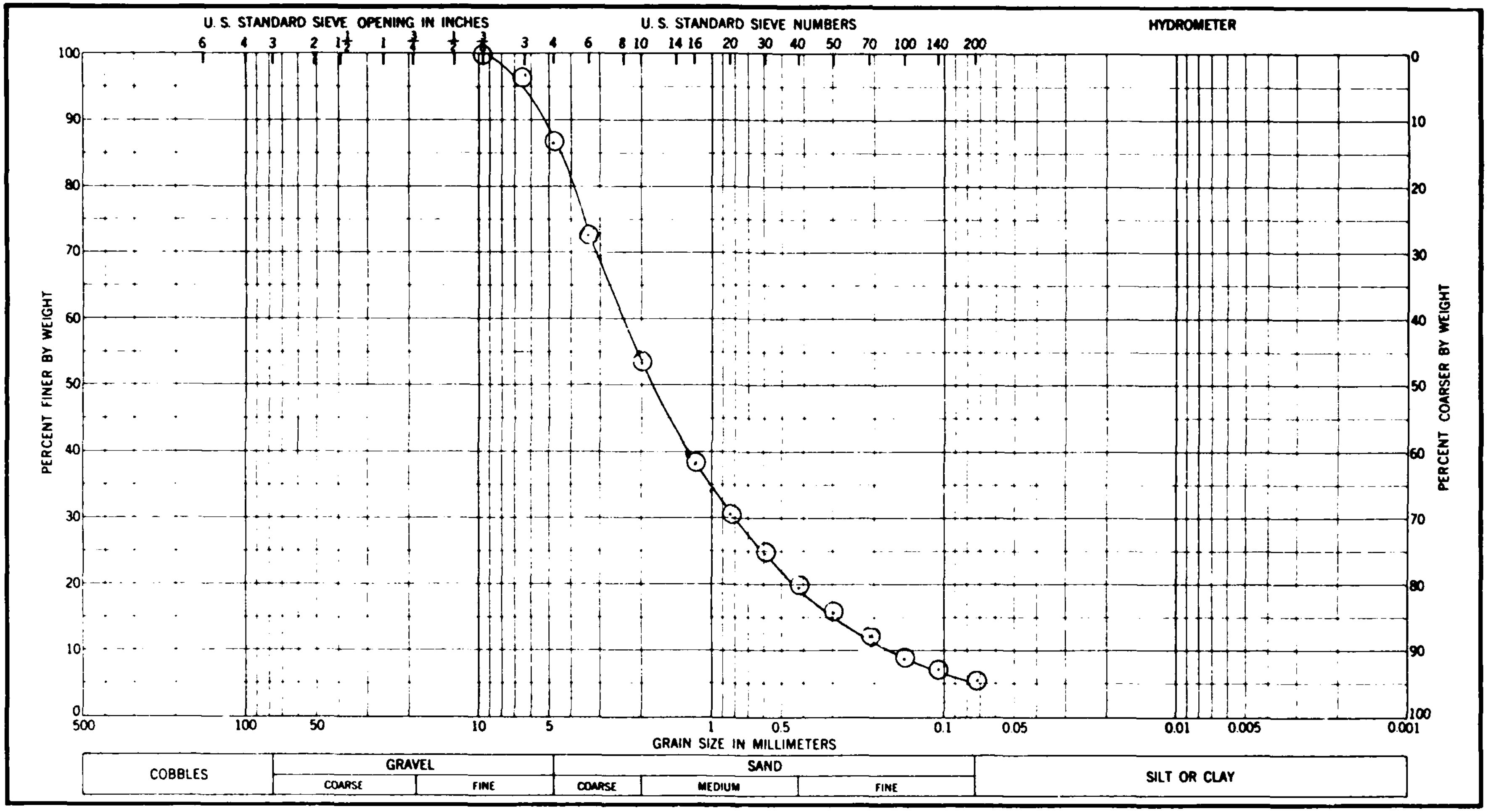

Figure 22. Movable-bed gradation curve

20 ft apart and were supported by 2-in.-diam round steel pipe, located so as to cause minimal interference with flow. A light cart or carriage was built to roll along the rails, propelled by means of a hand crank, sprocket, and chain system attached to one of the wheels. A sounding rail was attached to the cart with two bolts, one over each wheel, to minimize deflection of the sounding rail by separation of the catwalk section of the cart from the sounding rail (Figure 23; note, this photograph was taken on another model study but the same design was used). A manually operated, aluminum sounding rod with a slide and pointer type dial was used on the sounding rail to record bottom elevations. The foot of the rod was a 2-in.-diam disk mounted on a ball and socket joint so it tended to position itself tangent to slopes and curves of the bottom (Figure 24).

Operation procedures

105. Model scour and fill were determined by subtracting after-testing soundings from before-testing soundings. The differences that gave negative values represented a lowering or scour of the bottom, while those resulting in positive values represented a rise or filling of the bottom. The plus and minus values were plotted on rectangular grid points, and a scour and fill map was made by connecting isopleths of change. These patterns of scour and fill then were used for comparison of different model conditions.

106. Initial model conditions were molded to reproduce the May 1975 prototype survey. Aluminum templates were made based on prototype data from this survey, and each test was started by molding the movable bed to these templates (spaced 2 ft apart). The model then was slowly filled with water, exercising care to avoid erosion of the coal during filling. The bed was sounded with the rod and hand-driven cart described above and soundings were recorded manually. Computations for scour and fill were performed with as many as 4,000 points sounded on each survey or set of soundings. Hydrographic maps showing scour and fill were plotted and contoured by hand.

107. Before each test was started, the controllable test parameters were chosen and the model control equipment was set to reproduce the desired physical parameters (i.e. wave direction, wave height and period, tide range, and mean tide level). Wave sequence (the amount of time each wave generator was operated) was selected and was usually based on seasonal variations in the wave climate and an attempt to approximately simulate the variation in littoral drift. Beach feeding for littoral drift simulation was based on

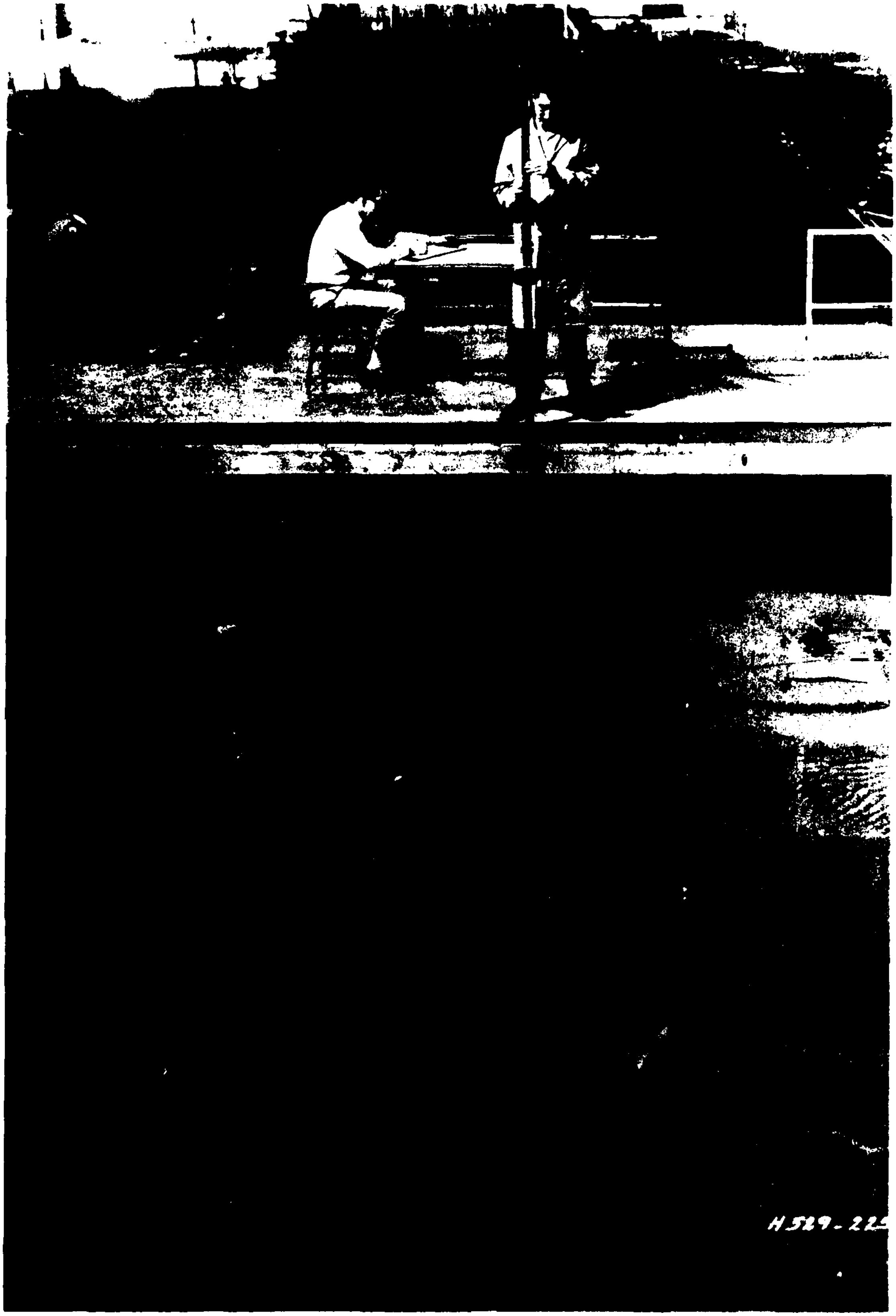

Figure 23. Sounding system (from a previous study)

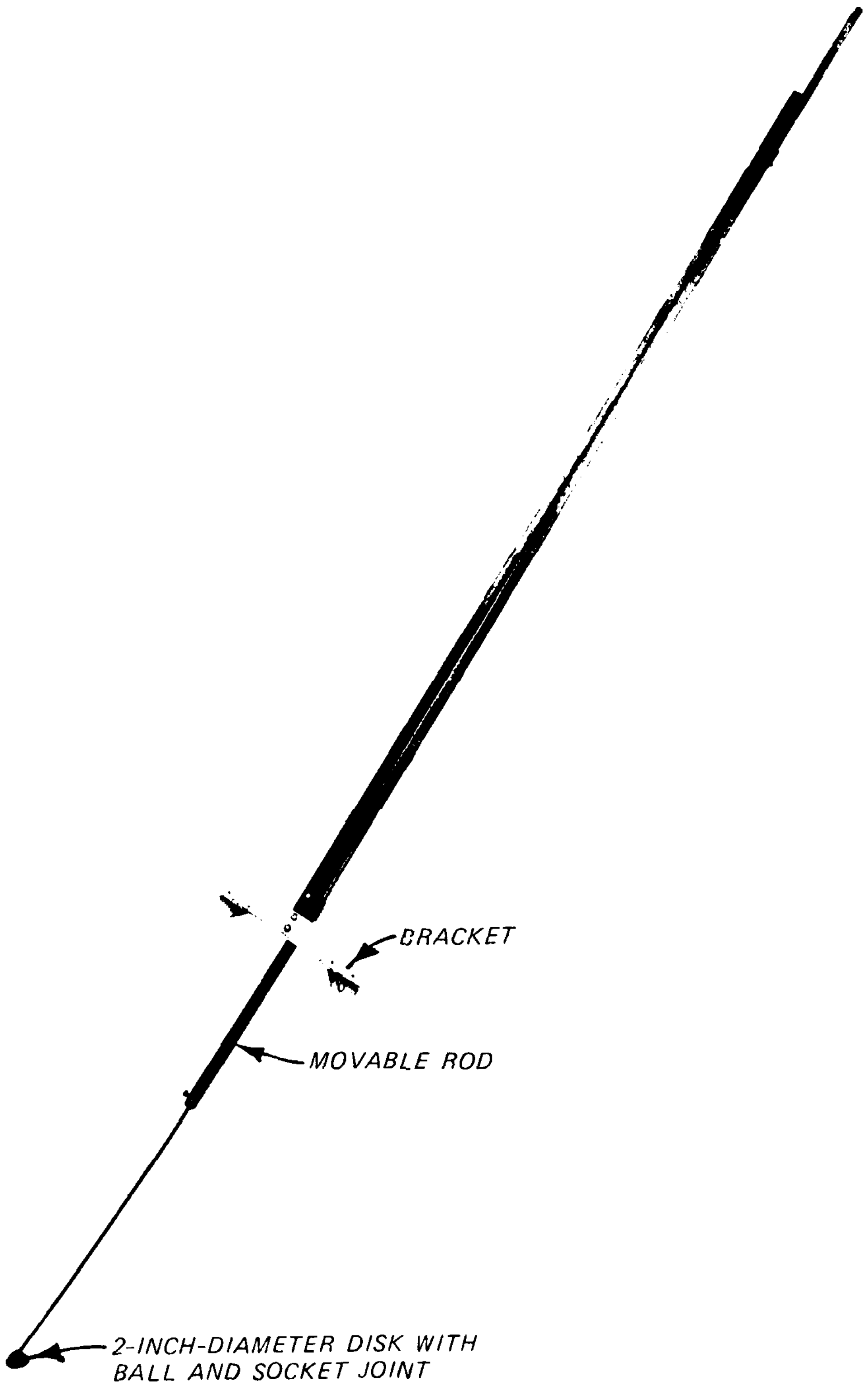

Figure 24. Sounding rod

demand feeding. Two areas were selected, one on each side of the inlet where the movable-bed and fixed-bed portions met. These two areas were kept to about the same shape and level throughout the test by the beach feeding procedure.

108. The model was operated for normal tide condition, an ebb storm surge, and a flood storm surge. The ebb surge was set up with a constant flow from the bay to the ocean area, while the flood surge was set up with a constant flow from the ocean area to the bay area.

109. After construction of the movable bed was completed, testing was begun using the scour and fill patterns observed from the prototype aerial photographs to adjust the model. Tests 1-10 were conducted to determine the necessary parameters for the proper model operation. The wave conditions (sequence, period, height, etc.) were changed as tide variables (tide levels, ebb flow time, flood flow time, etc.) were changed. These tests were conducted to produce scour and fill conditions in the model comparable to prototype scour and fill trends. Since the main concern of the movable-bed study was to compare the effects of the storm surges for base conditions and the proposed improvements to the inlet, no attempt was made to produce a detailed verification of the movable-bed model. Six tests were run after a satisfactory scour and fill trend was established. Tests 11 and 14 were run using normal tide conditions, while Tests 12, 13, 15, and 16 were run for storm surges. A detailed description of these tests follows.

Test 11

110. This test was conducted to obtain scour and fill patterns for base (existing) conditions. The initial condition survey is shown in Plate 348. The tide range was 3 ft (extending from a high water of +1.8 ft NGVD to a low water of -1.2 ft NGVD), with test waves of 8.5 sec, 1.4 ft from S79°E, and 8.5 sec, 1.4 ft from N40°E. The model was operated in the following sequence.

a. The tide generator was started and run for 2-1/4 cycles with waves from N40°E. The tide and waves were stopped at low water so as to be in a maximum ebb flow condition.

b. The model was kept in the maximum ebb condition with no waves for 30 min.

c. The model was run for 1-1/2 tidal cycles with waves from S79°E. Tide and waves were stopped at high water so as to be in maximum flood flow.

d. The model was kept in the flood condition with no waves for 30 min.

e. The model was run for 2-1/2 tidal cycles with waves from N40°E, then tide and waves were stopped at low water.

f. The model was kept in the ebb condition with no waves for 30 min.

g. The model was run for 1-1/2 tidal cycles with waves from S79°E, then tide and waves were stopped at high water.

h. The model was kept in the flood condition with no waves for 30 min.

i. After completion of this 30 min of flood flow, the tide was started and run to slack water and stopped. This completed the test. The model then was sounded (Plate 349) and a scour and fill map was plotted (Plate 350). A comparison of Plates 347 and 350 shows there were some locations of similarity of scour and fill. For example, the inside shoreline of the south shoulder of the inlet showed scour as did the prototype and the region along the oceanside shoreline of the north shoulder indicated some fill. Locations in the oceanward portion of the inlet had some similarity in juxtaposition of fill and scour areas. However, the basic problem was the lack of prototype data as the aerial photographic analysis could not give any indications of change other than in shallow shoal areas or along the shoreline.

Test 12

111. Test 12 was conducted to reproduce the effects of one of the most severe storms ever to hit the Oregon Inlet area. This storm, which was an extratropical cyclone, occurred on 7 March 1962 and became known as the Ash Wednesday storm, producing the highest recorded ocean tide in the history of the study area. This surge was reproduced in the model using the May 1975 survey as the base condition to which the model was molded (Plate 351). The water levels in the bay and ocean were at the same level to begin the test. The programmers for the ocean and bay tide generators then were reset to generate the desired tide levels and thus head difference. The ocean tide level reached 8.0 ft NGVD and the bay tide was at 1.3 ft NGVD. When the flow stabilized, the wave generator was turned on to generate a moderate storm wave of 5.9 ft, 12 sec from N40°E. These conditions were continued until the trends of erosion or fill were noted (the approximate model time for these trends to develop was about 10 min); then the flow and waves were stopped. The bay and ocean levels were then equalized and the model was sounded (Plate 352). A comparison of the scour and fill map (Plate 353) with initial conditions (Plate 351) shows that the entrance migrated to the north

slightly and began to erode Bodie Island. The channel area scoured at the main inlet throat area and shoaled on the Pea Island side of the inlet throat. Both Pea Island and Bodie Island beach areas were eroded. Old House Channel had begun to shoal, causing the navigation channel to shift more toward Davis Slough which indicated erosion. Maximum scour and/or fill of 9 ft or more was noted. The trend to erode Bodie Island noted in this test most likely occurred in the prototype. Examination of Photo 8, taken about one week after the storm, indicates that there may have been scour in this region. Shoal orientation in Photo 8 indicates that strong flood currents had occurred near the tip of Bodie Island. An analysis by the Wilmington District (USAED, Wilmington 1980) also indicated that the storm caused a widening of the inlet, resulting from erosion of the northern shoulder of the inlet.

Test 13

112. Test 13 was conducted to reproduce the effects of Hurricane Donna which passed through the area on 11-12 September 1960. The path of the hurricane passed directly over the long axis of Pamlico Sound, thus causing the highest bay tide ever recorded in the sound. This storm surge was reproduced in the model in the following manner. The model was molded to the base condition (May 1975), flooded to equal levels in the ocean and bay areas, and sounded (Plate 354). The ocean tide generator then was set to generate a -1.9 ft NGVD elevation and the bay generator was set to generate a +7.2 ft NGVD elevation. These flows were allowed to stabilize and the wave generator was started, reproducing a 6.9-ft, 12-sec wave from S79°E. Trends in the bed movement caused by the storm developed in approximately 10 min (model time). Both wave generator and tide generator were then stopped and the bay and ocean levels allowed to equalize. The model was sounded (Plate 355) and a scour and fill map was plotted (Plate 356). Test results show that the main channel migrated to the south and completely scoured out the offshore shoal that existed on the base condition along the southern side of the channel. There was little change along the beach of Pea Island. The inland point of Pea Island was completely scoured away, thus allowing the channel to move in that direction. The main channel location at the beginning of the test shoaled considerably during the test. The navigation channel through the bridge section migrated in a southerly direction, thus allowing Old House Channel to shoal toward the bridge section. There was a large scour in the main channel at the throat of the inlet, as shown in Plate 356. The beginning

survey showed a -30 ft contour in the throat while the final survey showed a -60 ft contour. There was scour along Bodie Island, mainly on the beach side to the south of the Coast Guard Station. This area scoured from a 0 elevation to a 36-ft depth. The offshore fill pattern, as shown in Plate 356, resembled a lunate bar.

Test 14

113. Test 14 was run using the same model procedure as Test 11, the only difference being that Test 14 had the jetties installed. Jetty alignment and location are shown in Figure 25. Results for Test 14 are shown in Plates 357-359. The effects of the jetties can be seen by comparing Plate 359 with Plate 350. The scour and fill areas in the throat of the inlet are almost the same. The scour along the outer end of the north jetty and the shoal area beyond the jetty are in the same areas as the smaller scour and shoal areas of the base test. With jetties installed, there seems to be a trend developing toward scouring a channel between the two jetties. As stated previously (fixed-bed portion of this report), a channel will be dredged between the jetties upon completion of jetty construction and this test indicates that this channel will tend to stabilize in a central position between the jetties. The inlet gorge was deepened and some scour was noted along Pea Island just bayward of the terminus of the south jetty.

Test 15

114. Test 15 was conducted to show the effects of a flood flow hurricane surge similar to that of the Ash Wednesday storm on the jetty system. Test conditions were the same as those for Test 12 except that the jetties were installed. Initial and final soundings are shown in Plates 360 and 361. The scour and fill patterns developed in Test 15 (Plate 362) show that most of the flow is diverted toward the north jetty, causing scour all along this jetty, with a shoal building along the south jetty. This was similar to the base test (Plate 353) except that the scour extended farther seaward. The shoal area that exists to the south side of the channel area in the base condition diverts the flow toward the north jetty at the beginning of the test, thus causing a continuous scour toward the north jetty. Oregon Inlet channel developed a heavy shoal on the bay side of the bridge, causing the channel through the navigation span to shift toward Davis Slough. The dike placed on Bodie Island from the end of the bridge to the north jetty eliminates the threat of any new breaks occurring on the beach in that area. The dike

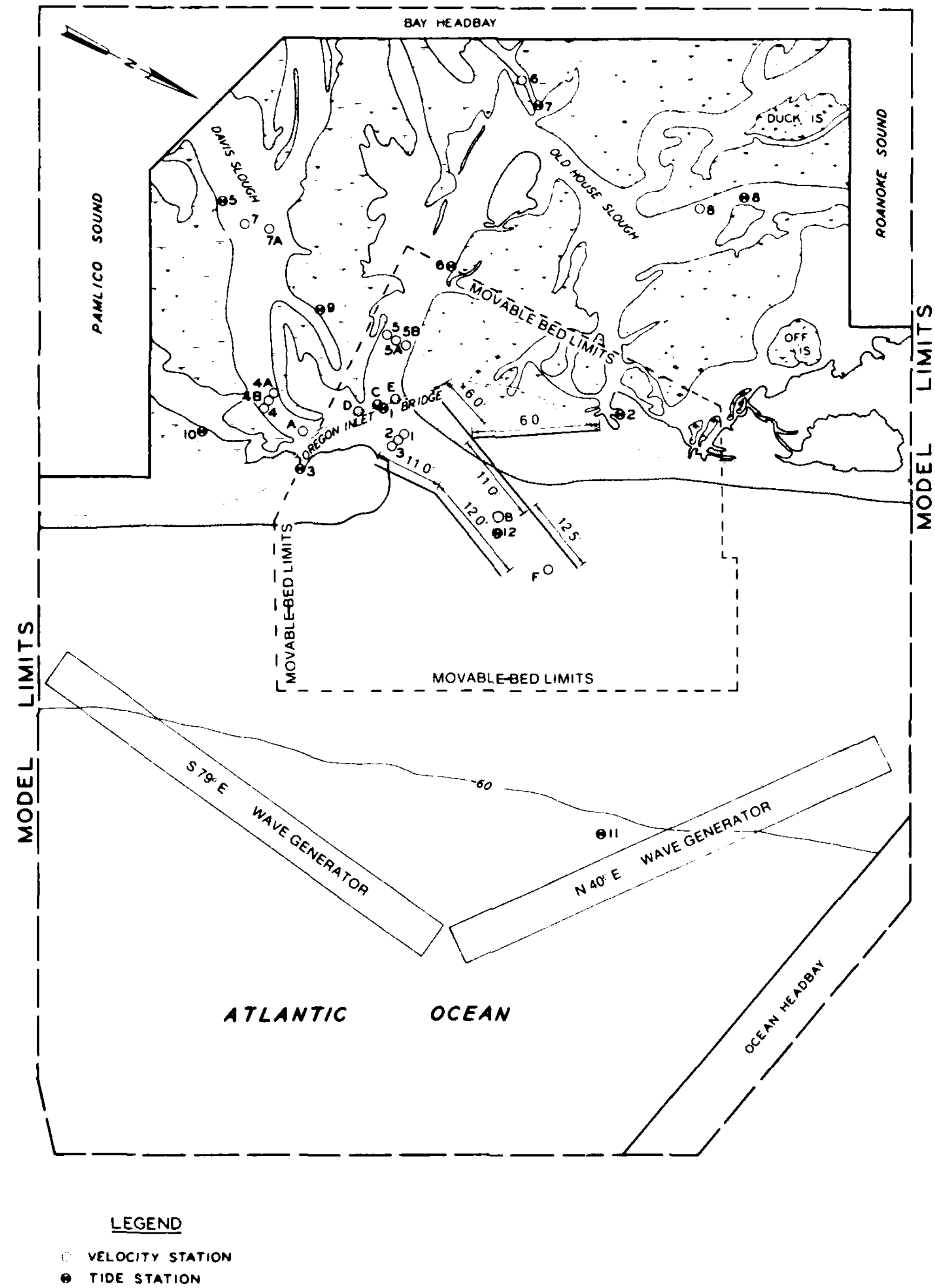

Figure 25. Movable-bed testing conditions

diverts the flow back around the north jetty into the channel area between the jetties.

Test 16

115. Test 16 subjected the jettied entrance to the ebb flow storm conditions representative of those that occurred on 12 September 1960 (Hurricane Donna). Test conditions were the same as Test 13, the only difference being that the jetties were installed in Test 16. Initial and final soundings are shown in Plates 363 and 364. Comparison of the scour and fill map for Test 16 (Plate 365) with the scour and fill map for Test 13 (Plate 356) shows that the jetties tended to stabilize the inlet. The scour that created an opening through the beach or Bodie Island at the northern end of the bridge in Test 13 also existed in Test 16. The additional scour areas along Bodie Island from the end of bridge toward the south point of the island were eliminated with the jetties installed. The shoal area that was produced in Test 13 from the channel southward toward Pea Island was confined to the area north of the south jetty as shown in Plate 365. The shoal on the north side of the channel toward Bodie Island was similar in both tests.

PART V: CONCLUSIONS

116. Based on the results of the model tests reported herein, the following conclusions have been reached:

a. The fixed-bed distorted-scale physical model was accurately calibrated with an extensive prototype data set of tidal elevations and velocities.

b. The alignment 2 jetties were selected from among the alignments tested since this orientation of jetties took advantage of the existing natural channel and minimized the probability of the formation of a secondary channel between the jetties.

c. Two jetty lengths were tested for alignment 2 and indicated little difference in hydraulic conditions, so the shorter jetty system was selected, saving 1,600 ft of jetty construction.

d. Three jetty spacings were examined for the alignment 2 jetties (5,000 ft, 3,500 ft, and 2,500 ft). A slight reduction in tidal prism was noted for the 2,500-ft spacing while the wider spacings effected no change in tidal prism. With an assumed scour channel in place between the jetties, there was no change in tidal prism from the base conditions for the 2,500-ft-wide jetty spacing. It is ecologically desirable to preserve the same tidal prism as occurs for the base condition.

e. The alignment 2, 2,500-ft and 3,500-ft spaced jetties reduced ebb and flood storm surge velocities at Bonner Bridge. The 5,000-ft spacing indicated slight increases in ebb and flood storm surge velocities. The addition of an assumed scour channel between the 2,500-ft spaced jetties indicated increases in ebb and flood storm surge velocities when compared with the base condition. This indicates that once the inlet adjusts to the jetties, the jetties would not significantly affect existing flooding potential near Oregon Inlet nor increase the potential for storm breaches of the barrier island north and south of the inlet.

f. The addition of rock bottom protection along the Bonner Bridge piling improved ebb current flow through the navigation channel under the bridge.

g. Effects of the jetties on flows through Bonner Bridge indicated no increase in scour potential at the bridge. Observation of surface current patterns during bay surge tests indicated high flow between the curved section of the north jetty and the bridge. Therefore it was necessary to extend the main trunk of the jetty 3,500 ft bayward to its intersection with the bridge. This would aid in maintaining horizontal control of the channel through the navigation span. The elevation of this extension was set low enough (+3.5 ft NGVD) to permit some flow during high surge

conditions to limit concentration of currents at other locations along the bridge.

h. Compared with tests of the selected jetty configuration, results of the bottom protection tests in which a 3.5-ft-thick by 100-ft-wide riprap mat was placed under the bridge indicated that:

   (1) Total flow volume through Oregon Inlet for normal tides was not significantly affected.

   (2) A slight increase of the percentage of flow through Oregon Inlet channel was noted. This slight redistribution would aid in maintaining authorized channel dimensions of the navigation channel under the bridge.

   (3) Velocities for storm surge conditions (flood direction only) were generally increased through the southern half of the bridge with the bottom protection in place.

i. The placement of sills in Davis and Middle Sloughs with the bottom protection did cause the desired result of diverting more flow into Oregon Inlet channel, but the tidal exchange from ocean to bay was significantly reduced.

j. Testing of the construction of the jetties in various sequences indicated that scour would likely occur at the jetty tips during construction for the sequences tested. Flood currents would contribute more significantly to this scour than ebb currents.

k. Sediment tracer tests showed that large fillets of sediment should accumulate on the outer side of each jetty before transport of material into the channel by movement around the jetty tips occurs.

l. Testing of jetty doors, which would facilitate dredge access to the sediment fillet from the protected backside of the fillet, indicated that ebb velocities were never higher than 2 fps and flood velocities would peak as high as 5 fps through the access doors. This was for a prefillet condition.

m. The movable-bed tests indicated that:

   (1) Though a detailed verification was not performed, the fill and scour trends observed in the model base test had similarities to those of the prototype.

   (2) Testing of the flood and ebb storm surges indicated areas of heavy fill and scour accompanying migration of the channel in the inlet for the nonjettied base condition.

   (3) Testing of the alignment 2 jetty system for normal tide and wave conditions indicated that some scour would occur along the channel side of the oceanward end of the north jetty though no change in the basic channel alignment was seen. Also the inlet gorge deepened

and some scour was noted along Pea Island just bayward of the terminus of the south jetty. Some sediment deposited oceanward of the north jetty tip but depths were greater than that of the channel.

(4) Testing of the alignment 2 jetty system with a flood storm surge indicated similar patterns of sediment erosion and deposition between the base and plan tests with the exception that the region of scour of the base test was extended farther seaward for the plan due to the confining of the currents by the jetties. Sediment movement patterns bayward were very similar between plan and base. The total amount of scour and fill was reduced for the plan ebb storm surge test as compared with that of the base ebb storm surge test, with the jetties providing greater stability and reducing the scour in the region north of the inlet.

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Table 1

Prototype Tidal Current Data

Station No.	Approximate Location N. Latitude	W. Longitude	Depths Recorded ft	Period Recorded
1	35°46'33.6"	75°32'08.9"	6, 12	10 May-16 Jun 75
2	35°46'33.2"	75°32'08.4"	6, 12, 18, 24	9 May-17 Jun 75
3	35°46'32.7"	75°31'54.0"	6, 12	9 May-16 Jun 75
4	35°45'04.5"	75°31'52.1"	6, 12	5 May-16 Jun 75
4A	35°45'43"	75°31'58"	6, 12	5 May-14 May 75
5	35°46'13.1"	75°32'47.02"	6	5 May-16 Jun 75
5A	35°46'20"	75°32'48"	6, 12	30 May-16 Jun 75
6	35°16'18"	75°34'56"	6	6 May-16 Jun 75
7	35°45'06"	75°33'06"	6	6 May-3 May 75
7A	35°45'13"	75°33'08"	6, 12	15 May-23 May 75
8	35°47'40"	75°34'44"	6	14 May-30 May 75
9	35°46'48"	75°34'33"	6	23 May-7 Jun 75

Table 2

List of Tide Gage Stations

Gage No.	Gage Name	Approximate Location N. Latitude	Approximate Location W. Longitude	Gage Zero ft mlw	Gage Zero ft NGVD
1	Oregon Inlet Bridge	35°46'24"	75°32'18"	0.81	1.67
2	Oregon Inlet Marina	35°47'46"	75°32'57"	2.34	2.30
3	U. S. Coast Guard Station	35°46'03"	75°31'32"	0.90	1.37
5	Davis Slough	35°44'55"	75°33'11:	1.49	1.77
6	Oregon Inlet Channel	35°46'24"	75°33'29"	1.71	2.03
7	Old House Channel	35°46'28"	75°34'55"	2.22	2.26
8	Roanoke Sound Channel	35°47'54"	75°34'57"	1.87	1.77
9	Level Platform No. 9	35°45'44"	75°32'45"	1.90	2.20
10	Pea Island	35°45'23"	75°31'32"	3.67	4.02
12	OAR Pressure Gage	35°47'18"	75°31'42"	Unknown	
	Jennette's Pier	35°54'36"	75°35'30"	1.1	2.77

Table 3

Normal Tidal Flow Through Oregon Inlet with and Without Jetties (Model Data)

Bay Channel	Inlet Condition: Base Test — Measured Flow, ft^3	Base Test — Percent of Total	Alignment 2 (2,500-ft spacing) — Measured Flow, ft^3	Alignment 2 (2,500-ft spacing) — Percent of Total
		Flood		
Oregon Inlet Channel	0.43×10^9	32.8	0.41×10^9	36.6
Middle Slough	0.54×10^9	41.2	0.43×10^9	38.4
Davis Slough	0.34×10^9	26.0	0.28×10^9	25.0
Total Flood	1.31×10^9	100.0	1.12×10^9	100.0
		Ebb		
Oregon Inlet Channel	1.00×10^9	34.7	0.85×10^9	32.6
Middle Slough	0.61×10^9	21.2	0.55×10^9	21.1
Davis Slough	1.27×10^9	44.1	1.21×10^9	46.3
Total Ebb	2.88×10^9	100.0	2.61×10^9	100.0

Table 4

Water-Surface Elevations During Simulated Storm Surge Tests

Model Tide Station Number and Location	Water-Surface Elevation (ft NGVD) During					
	Hurricane Donna 12 Sep 60			Ash Wednesday Storm 7 Mar 62		
	Base Test	Plan 2 2,500-ft Spacing Jettied Inlet	Jettied Inlet with Scour Channel	Base Test	Plan 2 2,500-ft Spacing Jettied Inlet	Jettied Inlet with Scour Channel
11 Ocean	-1.9	-1.9	-2.0	8.0	8.0	8.0
12 Bar Channel	1.8	2.1	0.6	7.5	3.9	4.4
1 Navigation Span	5.5	6.6	5.0	3.8	2.9	3.5
6 Oregon Inlet Channel	6.7	7.1	7.0	3.3	2.1	2.8
2 Marina	7.1	7.3	7.3	2.7	1.9	2.5
7 Old House Channel	6.9	7.2	7.2	2.5	1.5	2.5
8 Roanoke Sound Channel	7.2	7.4	7.5	1.3	0.4	1.6
3 Coast Guard Station	6.4	7.0	6.3	4.5	3.3	4.1
10 Pea Island	6.7	7.1	6.9	3.8	2.5	3.2
9 Middle Slough	6.6	7.0	6.8	3.7	2.4	3.1
5 Davis Slough	6.8	7.0	7.0	3.1	1.6	2.5

Table 5

Current Velocities During Simulated Storm Surges

Model Velocity Station Number and Location	Current Velocity (fps) During: Hurricane Donna 12 Sep 60 — Base Test	Hurricane Donna 12 Sep 60 — Plan 2 2,500-ft Spacing Jettied Inlet	Hurricane Donna 12 Sep 60 — Jettied Inlet with Scour Channel	Ash Wednesday Storm 7 Mar 62 — Base Test	Ash Wednesday Storm 7 Mar 62 — Plan 2 2,500-ft Spacing Jettied Inlet	Ash Wednesday Storm 7 Mar 62 — Jettied Inlet with Scour Channel
F End of Jetties	14.2	16.4	13.9	2.9	9.4	7.7
B Between Jetties	11.8	13.2	12.9	5.8	15.9	11.3
1 N. Side Gorge	7.2	8.6	10.7	11.1	11.1	9.5
2 Middle of Gorge	7.2	9.4	13.4	13.0	8.4	8.0
3 S. Side Gorge	8.2	9.2	14.4	5.5	13.1	8.7
C Navigation Span	7.1	6.3	9.9*	6.7	7.4	11.8*

* Test included bottom protection beneath bridge which increased velocities through the bridge relative to other conditions.

Table 6

Bottom Protection Tests

Test No.	Jetties ?	Bottom Protection	Sills	Navigation Gap Depth	Surface Current Photos	Storm Surge Velocities	Tides and Velocities
1*	No	No	No	Existing	Yes	Yes	Yes
2	No	Yes	No	Existing	Yes	No	Yes
7	No	Yes	Yes	Existing	Yes	No	No
12	Yes**	No	No	Existing	Yes	Yes	Yes
13	Yes	Yes	No	Existing	Yes	Yes	Yes
18	Yes	Yes	Yes	Existing	Yes	Yes	Yes
20	Yes	Yes	Yes	-40 ft	Yes	Yes	Yes
21	Yes	Yes	Yes	-35 ft	Yes	Yes	Yes
22	Yes	Yes	Yes	-30 ft	Yes	Yes	Yes
24	Yes	Yes	Yes	-20 ft	Yes	Yes	Yes
26†	Yes	Yes	No	Existing	Yes	Yes	Yes

* Base condition.

** Plan 2 jetties with dredged navigation channel.

† Put in extended fill on south end of north bank adjacent to navigation gap.

Table 7

Summary of Flow Distribution Through Major Channels at Bridge and Total Flow Through Gorge

Channel	Ebb, ft^3	Percent	Flood, ft^3	Percent
		Base Test		
Oregon Inlet	977×10^6	34.6	428×10^6	32.8
Middle Slough	611×10^6	21.2	540×10^6	41.4
Davis Slough	1274×10^6	44.2	337×10^6	25.8
Total	2882×10^6	100,0	1305×10^6	100.0
Flow through gorge	2906×10^6		1200×10^6	
		Test 12		
Oregon Inlet	850×10^6	32.5	408×10^6	36.7
Middle Slough	550×10^6	21.1	428×10^6	38.5
Davis Slough	1212×10^6	46.4	276×10^6	24.8
Total	2612×10^6	100.0	1112×10^6	100.0
Flow through gorge	2591×10^6		983×10^6	
		Test 13		
Oregon Inlet	886×10^6	35.6	459×10^6	39.9
Middle Slough	651×10^6	26.2	400×10^6	34.8
Davis Slough	951×10^6	38.2	290×10^6	25.3
Total	2488×10^6	100.0	1149×10^6	100.0
Flow through gorge	2163×10^6		973×10^6	
		Test 18		
Oregon Inlet	969×10^6	46.7	430×10^6	48.9
Middle Slough	529×10^6	25.5	303×10^6	34.5
Davis Slough	587×10^6	27.8	146×10^6	16.6
Total	2075×10^6	100.0	879×10^6	100.0
Flow through gorge	1887×10^6		831×10^6	

(Continued)

Table 7 (Concluded)

Channel	Ebb, ft^3	Percent	Flood, ft^3	Percent
	Test 20			
Oregon Inlet	1241×10^6	46.4	465×10^6	59.5
Middle Slough	576×10^6	21.5	159×10^6	20.4
Davis Slough	857×10^6	32.1	157×10^6	20.1
Total	2674×10^6	100.0	781×10^6	100.0
Flow through gorge	3270×10^6		1380×10^6	
	Test 21			
Oregon Inlet	1047×10^6	42.1	359×10^6	61.0
Middle Slough	530×10^6	21.3	137×10^6	23.3
Davis Slough	909×10^6	36.6	93×10^6	15.7
Total	2486×10^6	100.0	589×10^6	100.0
Flow through gorge	2392×10^6		1039×10^6	
	Test 22			
Oregon Inlet	1048×10^6	44.4	552×10^6	65.4
Middle Slough	485×10^6	20.6	187×10^6	22.1
Davis Slough	827×10^6	35.0	105×10^6	12.4
Total	2360×10^6	100.0	844×10^6	100.0
Flow through gorge	2081×10^6		1402×10^6	
	Test 24			
Oregon Inlet	1005×10^6	43.3	438×10^6	57.8
Middle Slough	527×10^6	22.7	203×10^6	26.8
Davis Slough	790×10^6	34.0	117×10^6	15.4
Total	2322×10^6	100.0	758×10^6	100.0
Flow through gorge	2168×10^6		1067×10^6	
	Test 26			
Oregon Inlet	784×10^6	33.0	318×10^6	33.3
Middle Slough	652×10^6	27.4	406×10^6	42.6
Davis Slough	940×10^6	39.6	230×10^6	24.1
Total	2376×10^6	100.0	954×10^6	100.0
Flow through gorge	(Did not compute)			

Table 8

Maximum Bottom Flood and Ebb Velocities in the Vicinity of the Bridge Span for Various Test Conditions

	Flood Velocity, fps					Ebb Velocity, fps				
Station	Test 18	Test 24	Test 22	Test 21	Test 20	Test 18	Test 24	Test 22	Test 21	Test 20
139	--	1.8	1.2	1.1	1.1	--	3.0	2.2	1.8	1.9
139-B	2.5	1.8	0.9	1.0	0.7	2.0	2.0	1.3	1.4	1.2
139-0	2.8	2.2	1.7	1.4	1.2	4.2	2.7	2.0	1.8	1.5
141	--	2.0	1.7	1.3	1.5	--	2.6	2.0	2.2	2.0
145	1.8	2.0	2.0	1.5	0.8	2.5	1.9	1.8	1.8	1.4
145-B	2.2	1.0	1.2	0.6	0.9	2.0	1.9	1.4	1.8	1.5
145-0	3.0	2.2	2.6	2.0	1.6	4.6	2.0	1.2	1.3	0.9
148	1.8	1.7	2.1	1.2	1.4	2.2	0.9	0.9	0.8	1.0
151	--	1.2	1.4	1.1	1.4	--	1.8	0.8	0.4	0.5
151-0	1.8	2.0	2.0	1.6	1.6	1.2	2.0	1.6	2.0	2.0
155	2.4	1.8	2.1	1.4	2.1	2.1	1.6	1.3	1.3	2.0
Average	2.3	1.8	1.7	1.3	1.3	2.6	2.0	1.5	1.5	1.4

Note: Test 18, existing depths at navigation gap.
Test 24, 20-ft depth at navigation gap.
Test 22, 30-ft depth at navigation gap.
Test 21, 35-ft depth at navigation gap.
Test 20, 40-ft depth at navigation gap.

Table 9

Conditions for Staged Construction Tests

Sequence No.	Portion of Jetty Completed South Jetty	North Jetty
1	1/4	1/4
1	1/2	1/2
1	3/4	3/4
1	4/4	4/4
2	1/4	0
2	1/2	0
2	3/4	1/4
2	4/4	1/2
2	4/4	3/4
3	1/4	0
3	1/2	0
3	3/4	0
3	4/4	0
3	4/4	1/4
3	4/4	1/2
3	4/4	3/4

Table 10

Maximum Velocities During Construction

Sequence No.	Construction Stage of Jetty		Sta F		Sta B		6-ft Depth						Sta A		Sta D		Sta E		6-ft Depth					
							Sta 1		Sta 2		Sta 3								Bridge		Sta 4B		Sta 5B	
	S	N	E	F	E	F	E	F	E	F	E	F	E	F	E	F	E	F	E	F	E	F	E	F
1	1/4	1/4	4.7	1.5	5.8	2.8	3.6	3.8	3.0	3.0	5.3	1.5	5.3	2.0	2.0	2.8	3.5	2.5	2.6	2.4	3.1	2.0	2.0	2.2
	1/4	1/2	5.7	1.9	4.4	5.6	3.2	3.5	2.5	3.0	5.0	1.6	5.0	1.9	2.0	2.4	2.5	2.1	2.5	1.8	3.0	1.9	1.9	2.1
	3/4	3/4	5.6	3.2	5.0	4.2	3.0	3.1	2.8	3.4	4.1	1.8	4.1	2.2	1.8	1.9	3.1	2.1	2.2	2.1	2.6	2.2	1.5	1.9
	4/4	4/4	4.5	5.1	5.0	4.0	3.0	3.0	2.6	3.5	4.3	1.8	4.2	2.1	1.6	2.3	2.5	2.6	2.8	2.0	2.7	2.5	1.9	2.1
	Average		5.1	2.9	5.1	4.2	3.2	3.4	2.7	3.2	4.7	1.7	4.7	2.1	1.9	2.4	2.9	2.3	2.5	2.2	2.9	2.2	1.8	2.1
2	1/4	0	4.7	1.5	5.2	2.7	3.4	3.8	3.0	3.0	5.8	1.2	5.0	2.0	2.1	2.8	3.1	2.4	2.9	2.4	3.2	2.0	2.0	2.2
	1/2	0	5.8.	2.4	5.3	4.1	2.9	3.0	2.7	3.4	4.6	2.0	4.8	2.2	2.0	2.3	3.9	2.4	2.9	2.0	3.0	2.3	1.6	2.3
	3/4	1/4	5.7	2.5	5.5	3.8	3.2	3.0	3.1	3.0	5.3	1.9	4.5	2.2	2.0	2.1	3.5	2.0	1.9	2.0	5.2	2.3	1.7	1.9
	4/4	1/2	5.0	3.0	4.6	4.5	3.1	3.9	2.5	3.2	4.3	1.9	4.3	2.5	3.2	2.5	1.9	2.3	2.9	1.9	2.4	2.2	2.1	2.2
	4/4	3/4	5.[illegible]	3.5	4.8	4.2	3.1	3.4	2.7	3.0	4.3	1.6	4.3	2.2	1.9	2.1	3.0	2.3	2.1	2.2	2.4	2.2	2.1	2.2
	Average		5.3	2.6	5.1	3.9	3.1	3.4	2.8	3.1	4.9	1.7	4.6	2.2	2.2	2.4	3.1	2.3	2.5	2.1	3.2	2.2	1.9	2.2
3	1/4	0	4.7	1.5	5.2	2.7	3.4	3.8	3.0	3.0	5.8	1.2	5.0	2.0	2.1	2.8	3.1	2.4	2.9	2.4	3.2	2.0	2.0	2.2
	1/2	0	5.1	2.1	5.7	4.1	3.0	2.9	3.5	2.9	4.6	1.9	4.8	2.2	1.9	2.4	4.0	2.6	2.6	2.0	3.0	2.25	1.75	2.3
	3/4	0	5.3	2.4	5.7	4.9	3.2	2.6	3.4	2.9	4.9	2.0	4.8	2.5	1.8	2.1	3.0	2.7	2.5	2.2	2.7	2.25	1.9	2.4
	4/4	0	5.1	2.9	5.0	3.6	3.5	2.5	3.0	3.8	4.9	2.0	4.9	2.4	2.2	1.8	2.0	2.2	2.6	1.9	3.3	2.5	2.0	2.1
	4/4	1/4	5.5	3.0	5.3	3.9	3.2	3.2	2.8	3.5	5.1	2.0	4.9	2.5	3.4	2.0	3.1	2.0	2.6	2.3	3.0	2.5	1.8	2.1
	4/4	1/2	5.0	3.0	4.6	4.5	3.1	3.9	2.5	3.2	4.3	1.9	4.3	2.5	3.2	2.5	1.9	2.3	2.9	1.9	2.4	2.2	2.1	2.2
	4/4	3/4	5.5	3.5	4.8	4.2	3.1	3.4	2.7	3.0	4.3	1.6	4.3	2.2	1.9	2.1	3.0	2.3	2.1	2.2	2.4	2.2	2.1	2.2
	Average		5.2	2.6	5.2	4.0	3.2	3.2	3.0	3.2	4.8	1.8	4.7	2.3	2.4	2.2	2.9	2.4	2.6	2.1	2.9	2.3	2.0	2.2

Note: E = ebb flow; F = flood flow; N = north jetty; S = south jetty.

Table 11

Current Velocities During Jetty Door Test with Surge Conditions

Station No.	Depth	Velocity During Flood Surge fps	Velocity During Ebb Surge fps
N-1	Surface	8.2	7.6
	Middepth	Eddy	3.9
	Bottom	7.2	4.3
N-2	Surface	6.4	4.1
	Middepth	6.3	3.4
	Bottom	7.2	3.7
N-3	Surface	7.1	4.3
	Middepth	7.2	4.5
	Bottom	7.2	3.6
N-4	Surface	4.2	3.6
	Middepth	4.1	3.8
	Bottom	4.0	3.6
S-1	Surface	8.6	7.1
	Middepth	8.6	6.3
	Bottom	9.5	5.4
S-2	Surface	4.3	4.4
	Middepth	4.7	4.6
	Bottom	5.8	4.5
S-3	Surface	2.7	5.9
	Middepth	2.6	5.4
	Bottom	2.6	4.9
S-4	Surface	1.7	-0.9
	Middepth	1.7	0.8
	Bottom	1.6	0.9

Photo 1. Oregon Inlet, N. C., 24 January 1945

Photo 2. Oregon Inlet, N. C., 5 December 1949

Photo 3. Oregon Inlet, N. C., 31 May 1953

Photo 4. Oregon Inlet, N. C., 29 March 1955

Photo 5. Oregon Inlet, N. C., 4 May 1958

Photo 6. Oregon Inlet, N. C., 10 October 1958

Photo 7. Oregon Inlet, N. C., 16 August 1959

Photo 8. Oregon Inlet, N. C., 13 March 1962

Photo 9. Oregon Inlet, N. C., 3 May 1962

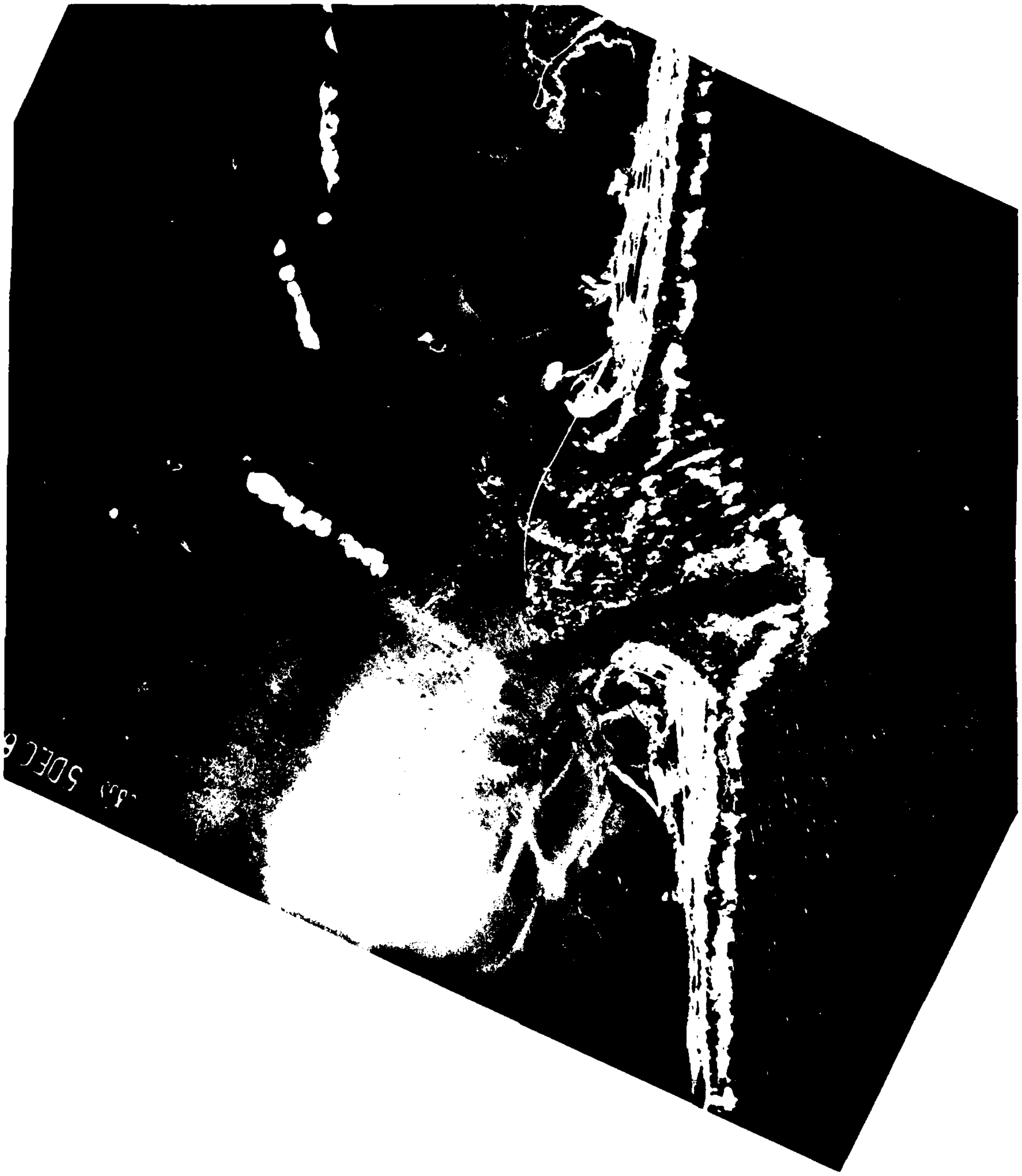


Photo 10. Oregon Inlet, N. C., 5 December 1962

Photo 11. Oregon Inlet, N. C., 25 October 1965

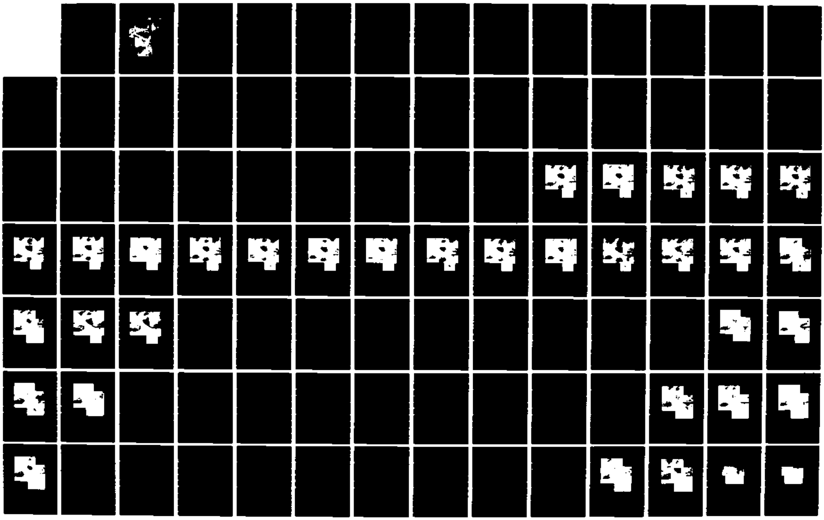
Photo 12. Oregon Inlet, N. C., 1 November 1971

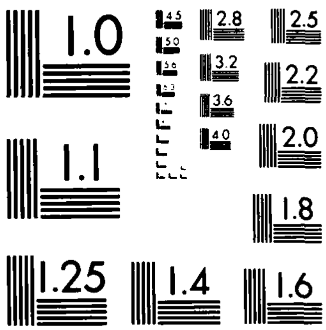
Photo 13. Oregon Inlet, N. C., 12 March 1975

Photo 14. Oregon Inlet, N. C., 7 October 1975

AD-A131 999 HYDRAULIC MODEL INVESTIGATION: FUNCTIONAL DESIGN OF CONTROL STRUCTURES FO..(U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS HYDRA.. 2/6

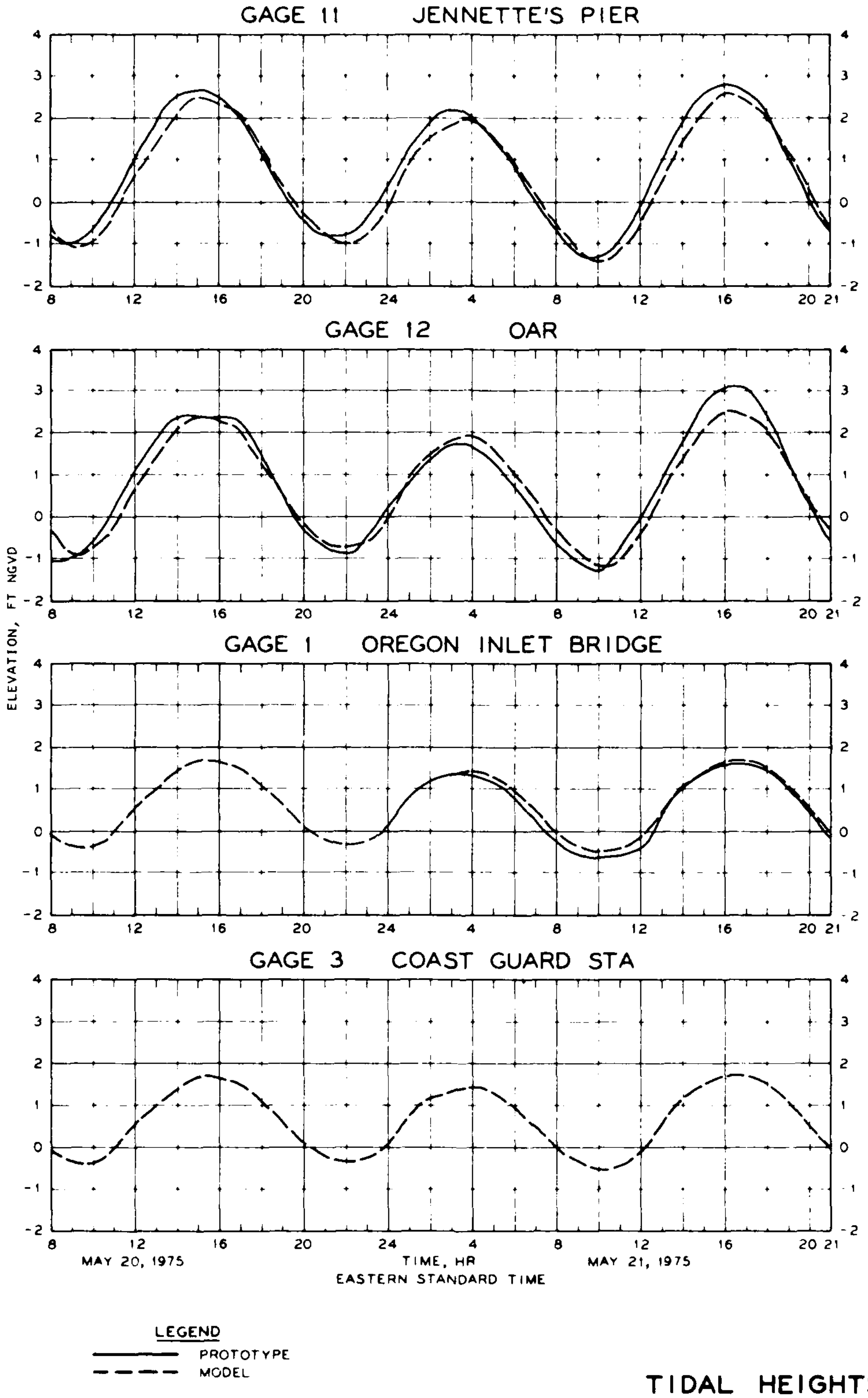
UNCLASSIFIED N W HOLLYFIELD ET AL. JUN 83 F/G 8/3 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

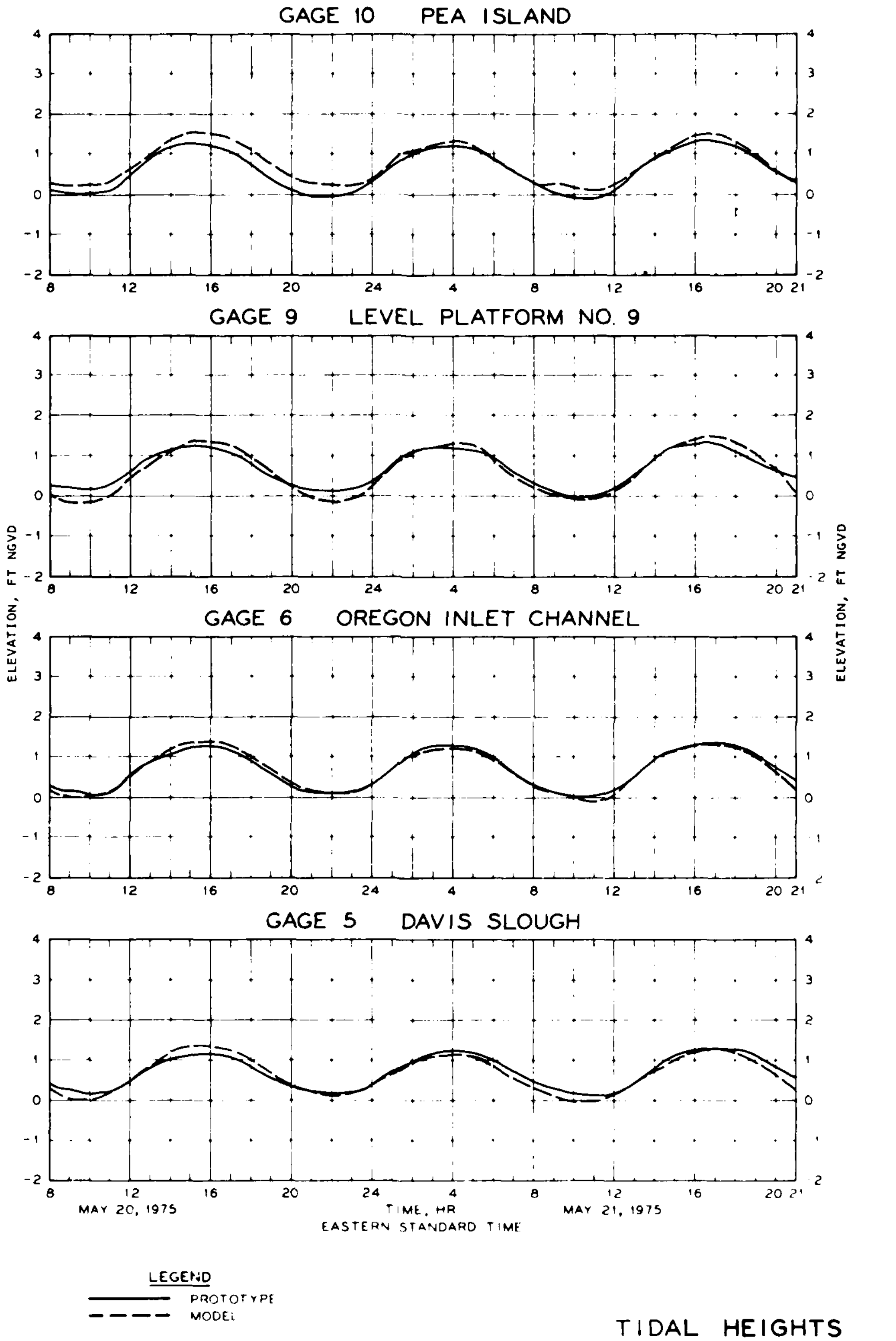
Photo 15. Oregon Inlet, N. C., 12 February 1976



NOTE: MODEL GAGE 11, JENNETTE'S PIER, IS LOCATED 9 MILES FROM PROTOTYPE OCEAN GAGE.
GAGE 12, OAR, ACTUAL DATUM IS UNKNOWN.

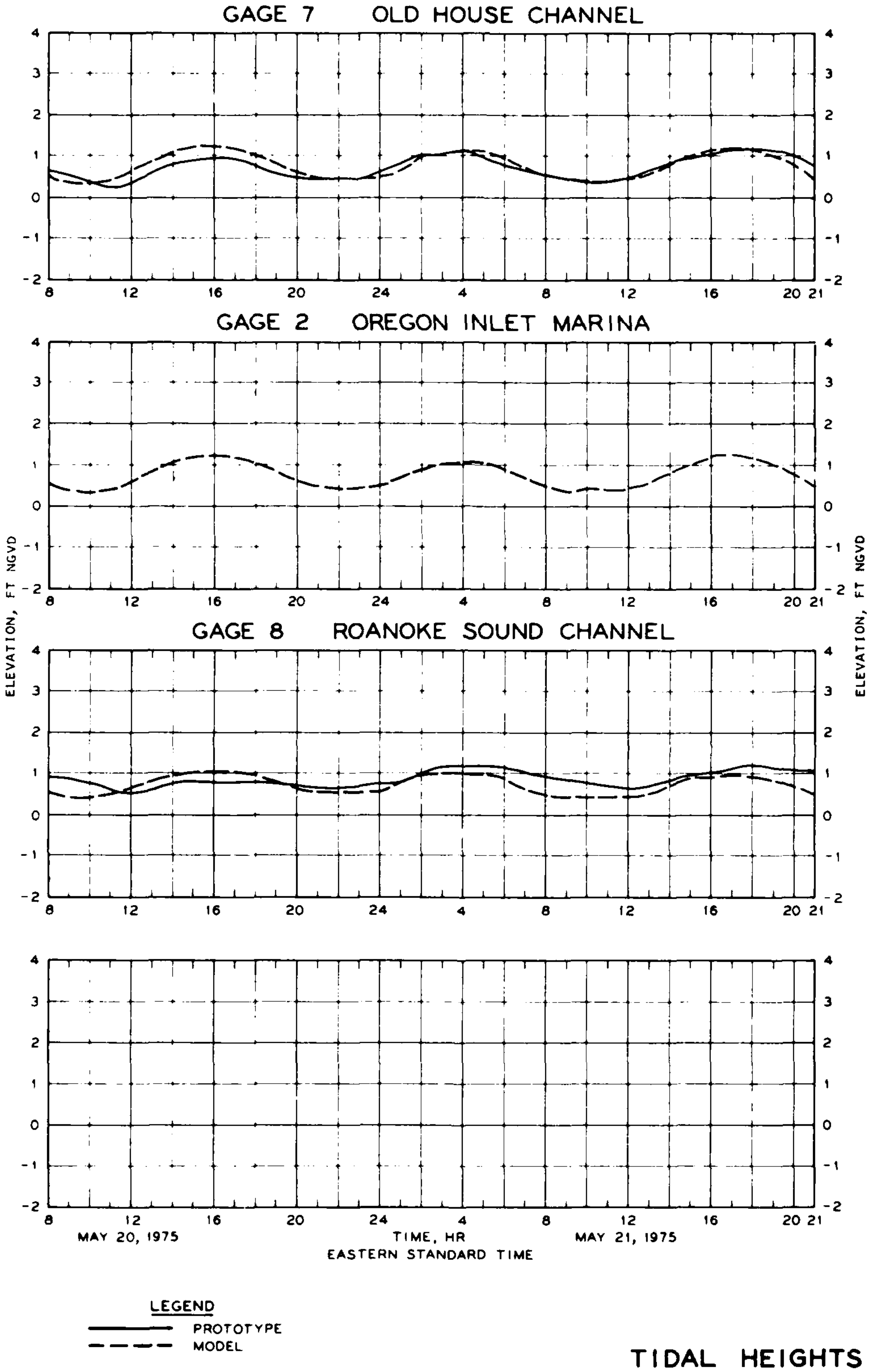
TIDAL HEIGHTS
MODEL VERIFICATION
GAGES 11, 12, 1, AND 3

PLATE 1



TIDAL HEIGHTS
MODEL VERIFICATION
GAGES 10, 9, 6, AND 5

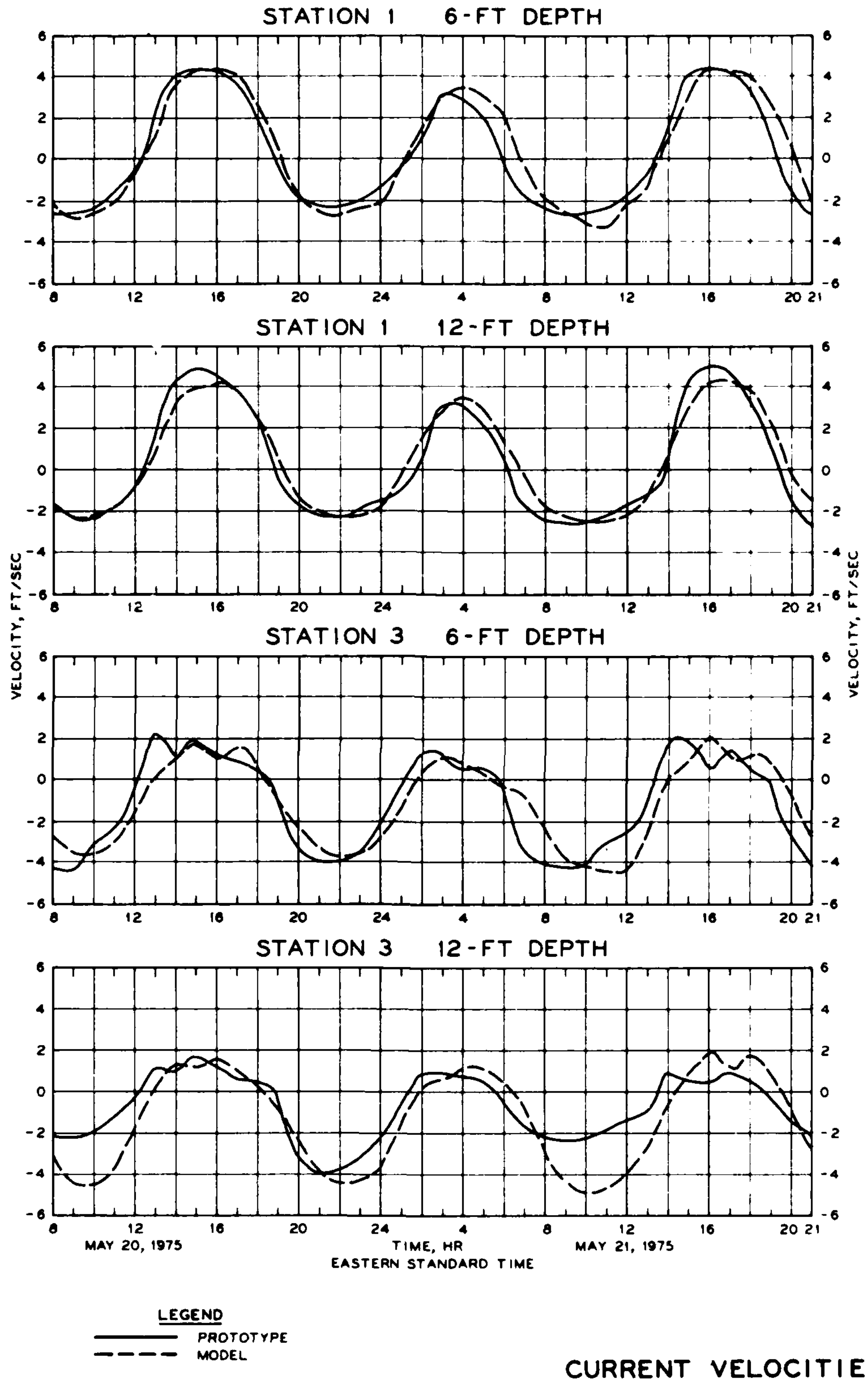
PLATE 2



TIDAL HEIGHTS

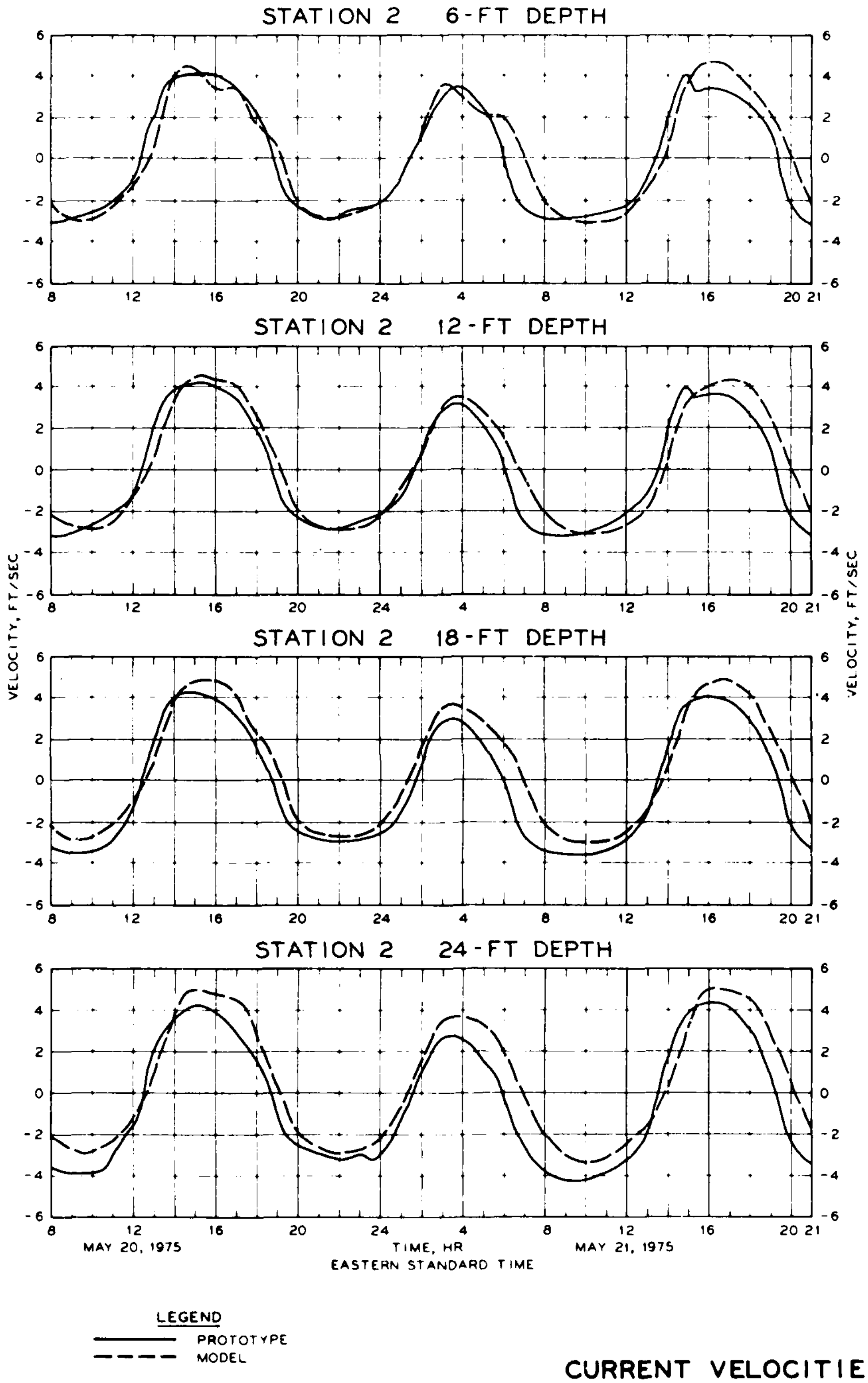
MODEL VFRIFICATION

GAGES 7, 2, AND 8

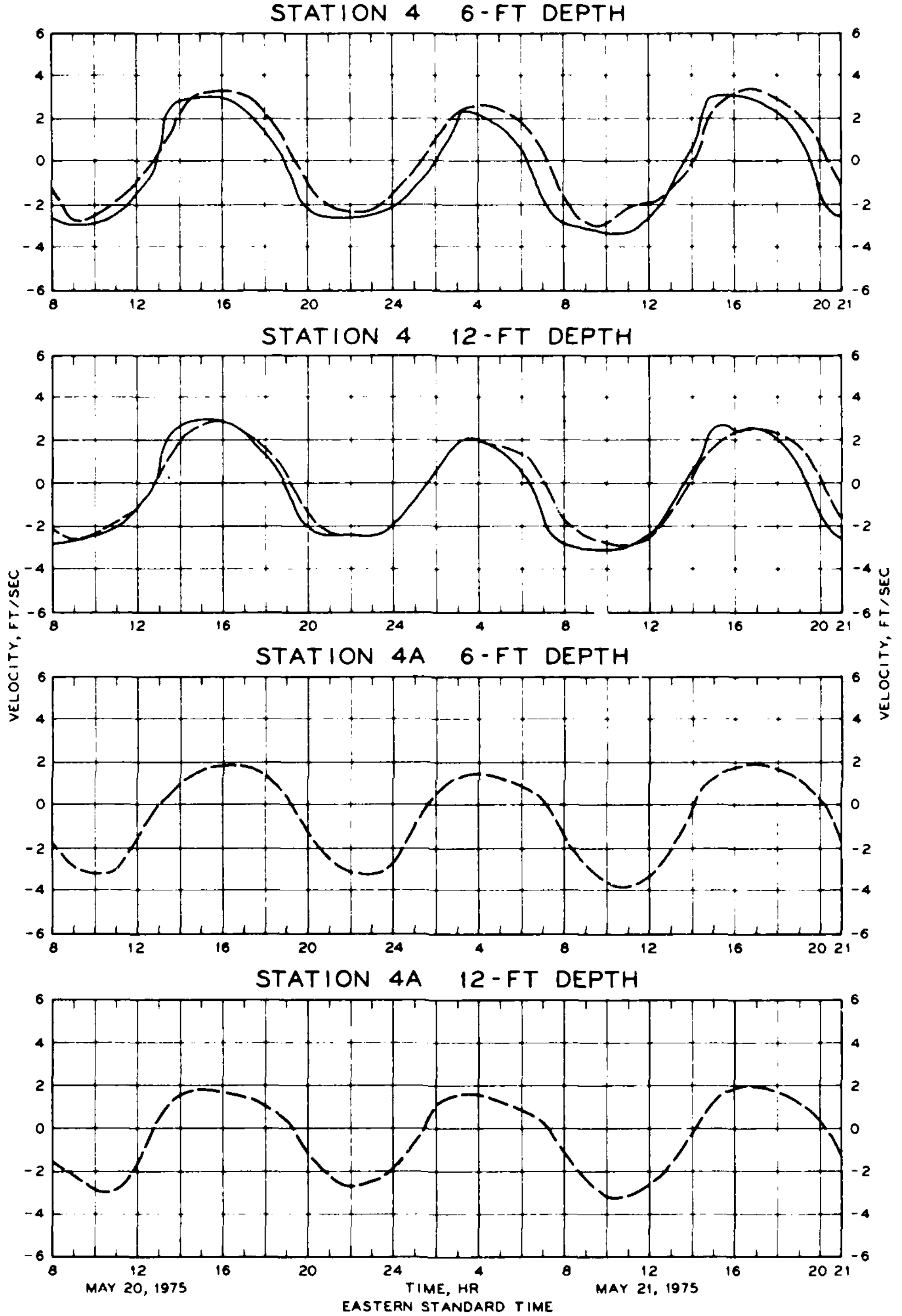


CURRENT VELOCITIES
MODEL VERIFICATION
STATIONS 1 AND 3

PLATE 4

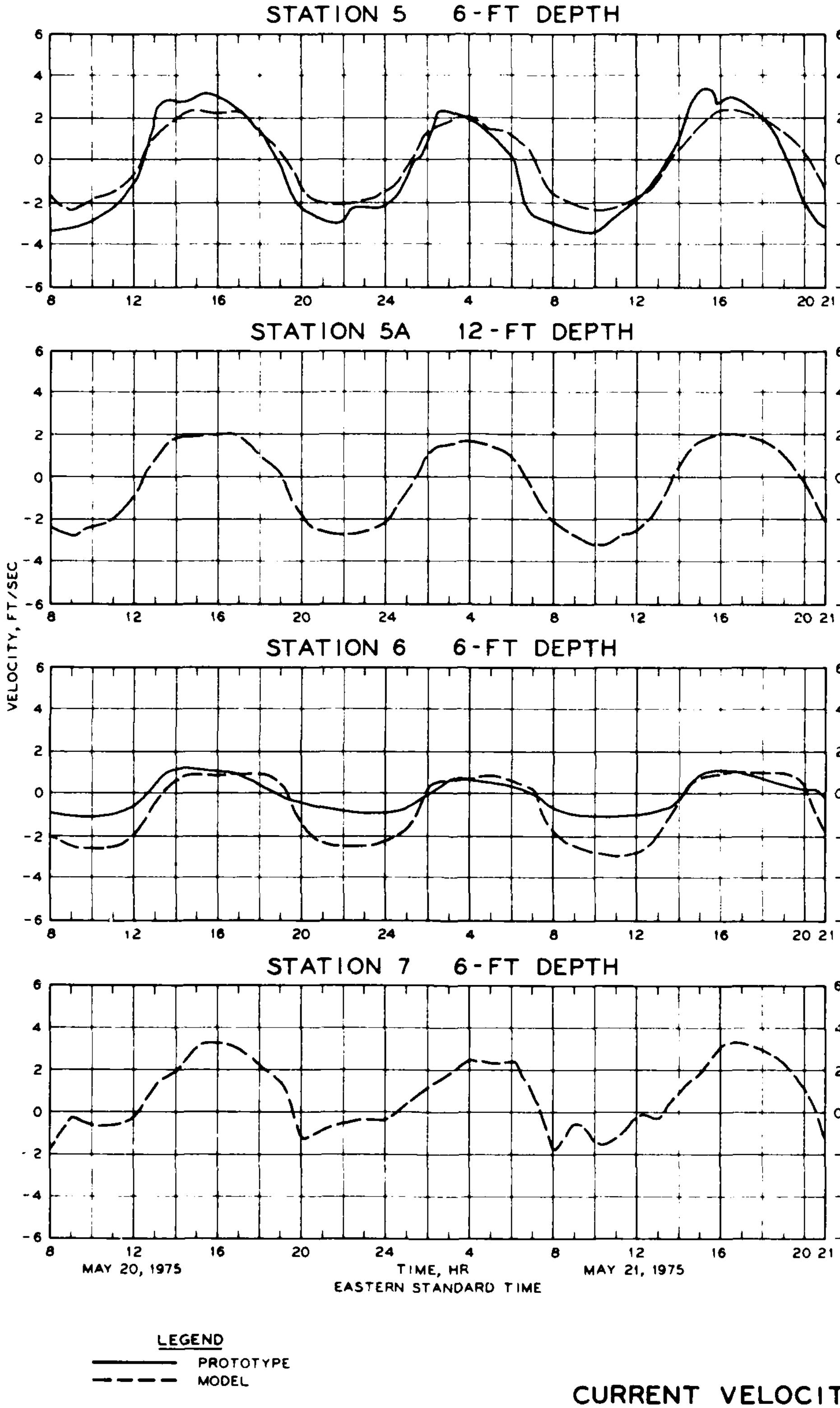


CURRENT VELOCITIES
MODEL VERIFICATION
STATION 2



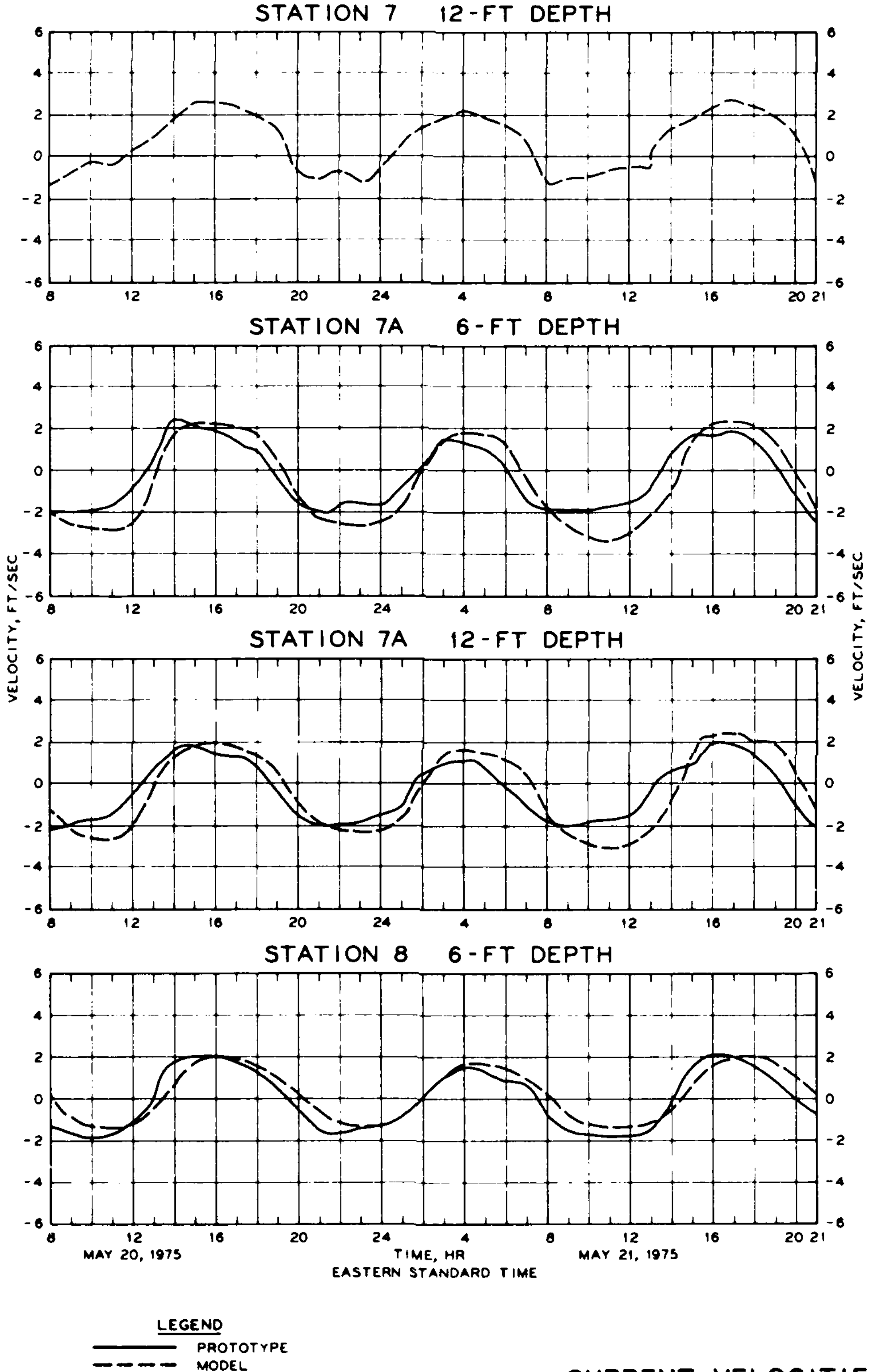
LEGEND
PROTOTYPE
MODEL

CURRENT VELOCITIES
MODEL VERIFICATION
STATIONS 4, AND 4A



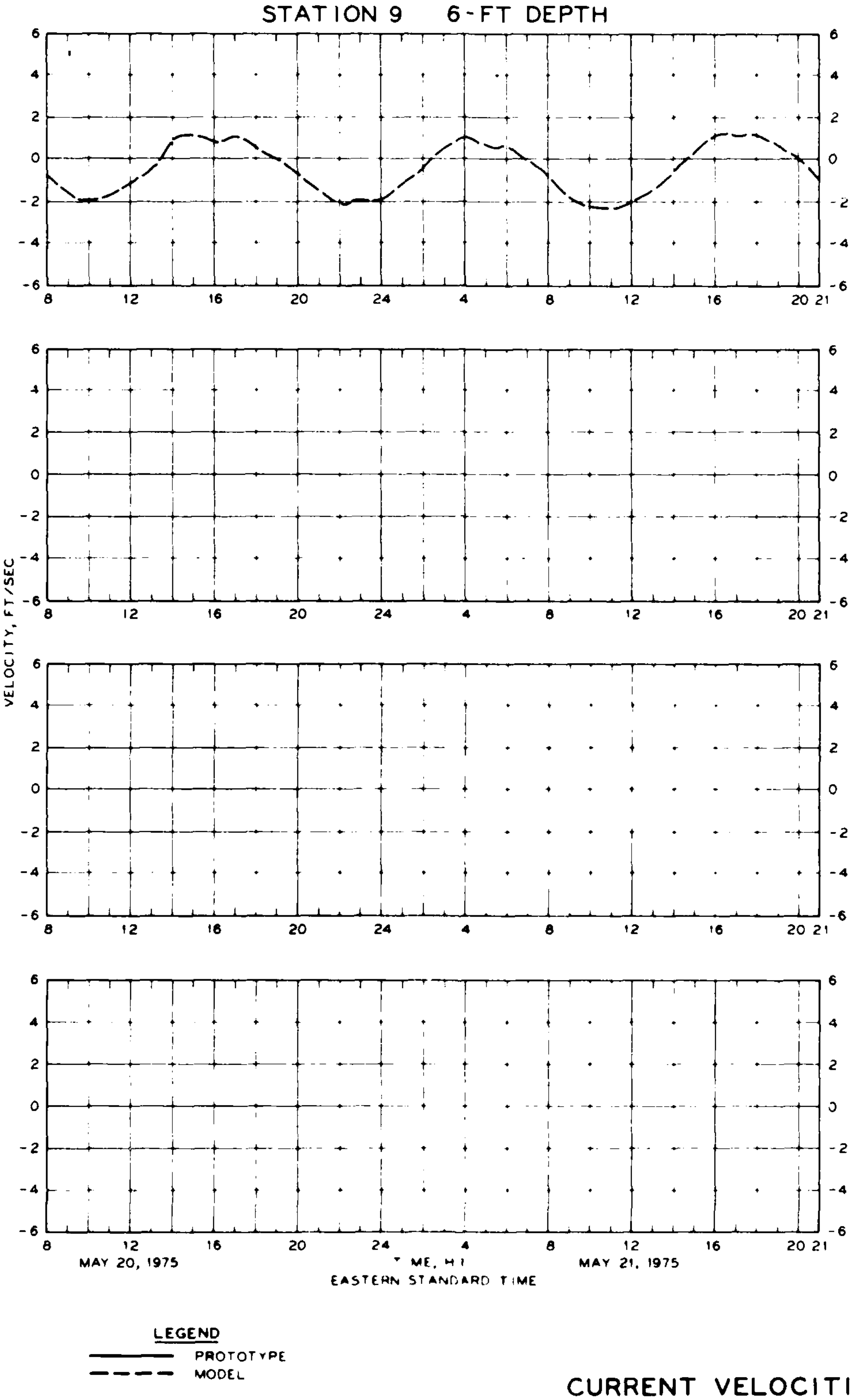
CURRENT VELOCITIES
MODEL VERIFICATION
STATIONS 5, 5A, 6, AND 7

PLATE 7

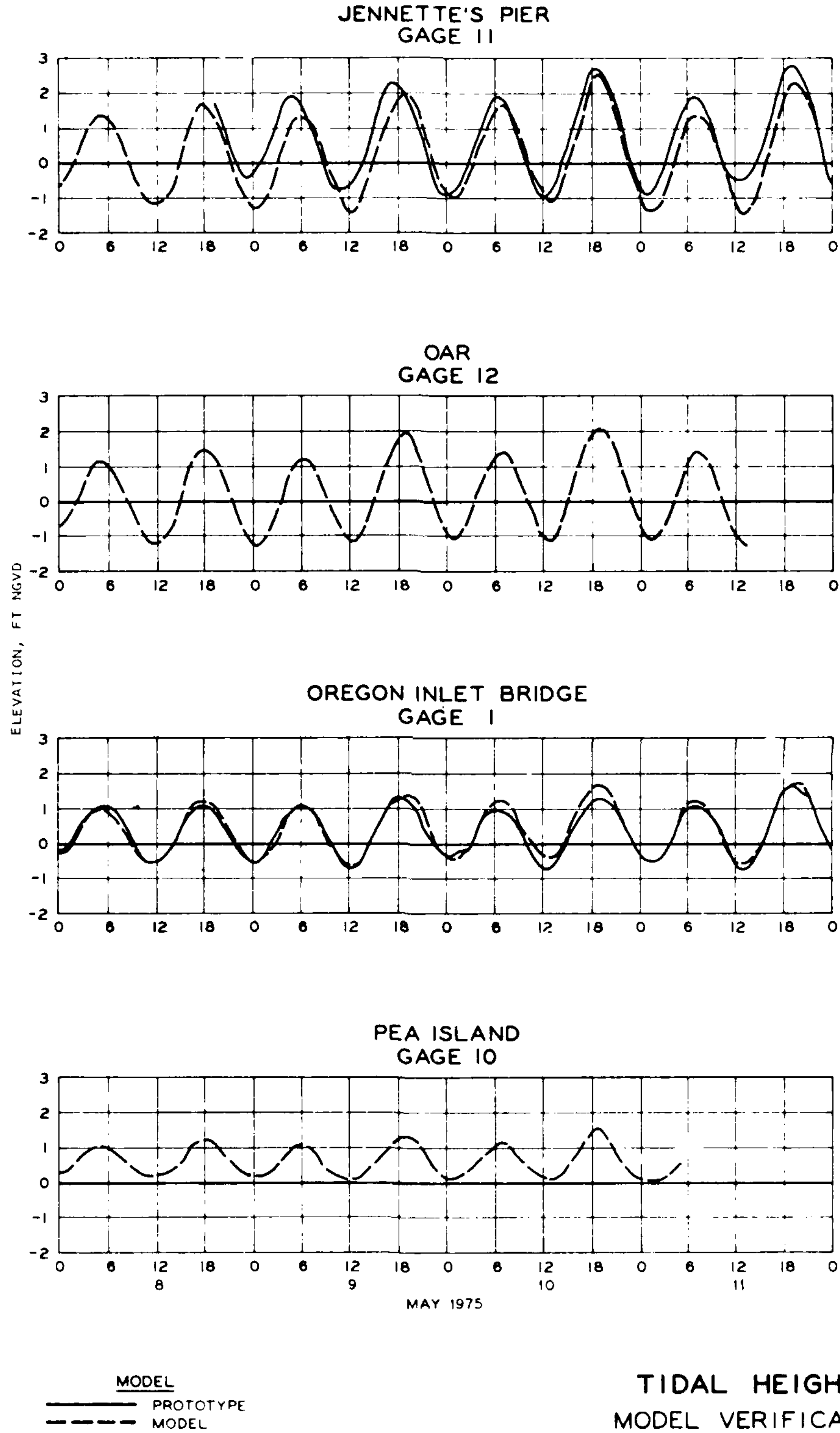


CURRENT VELOCITIES
MODEL VERIFICATION
STATIONS 7, 7A, AND 8

PLATE 8

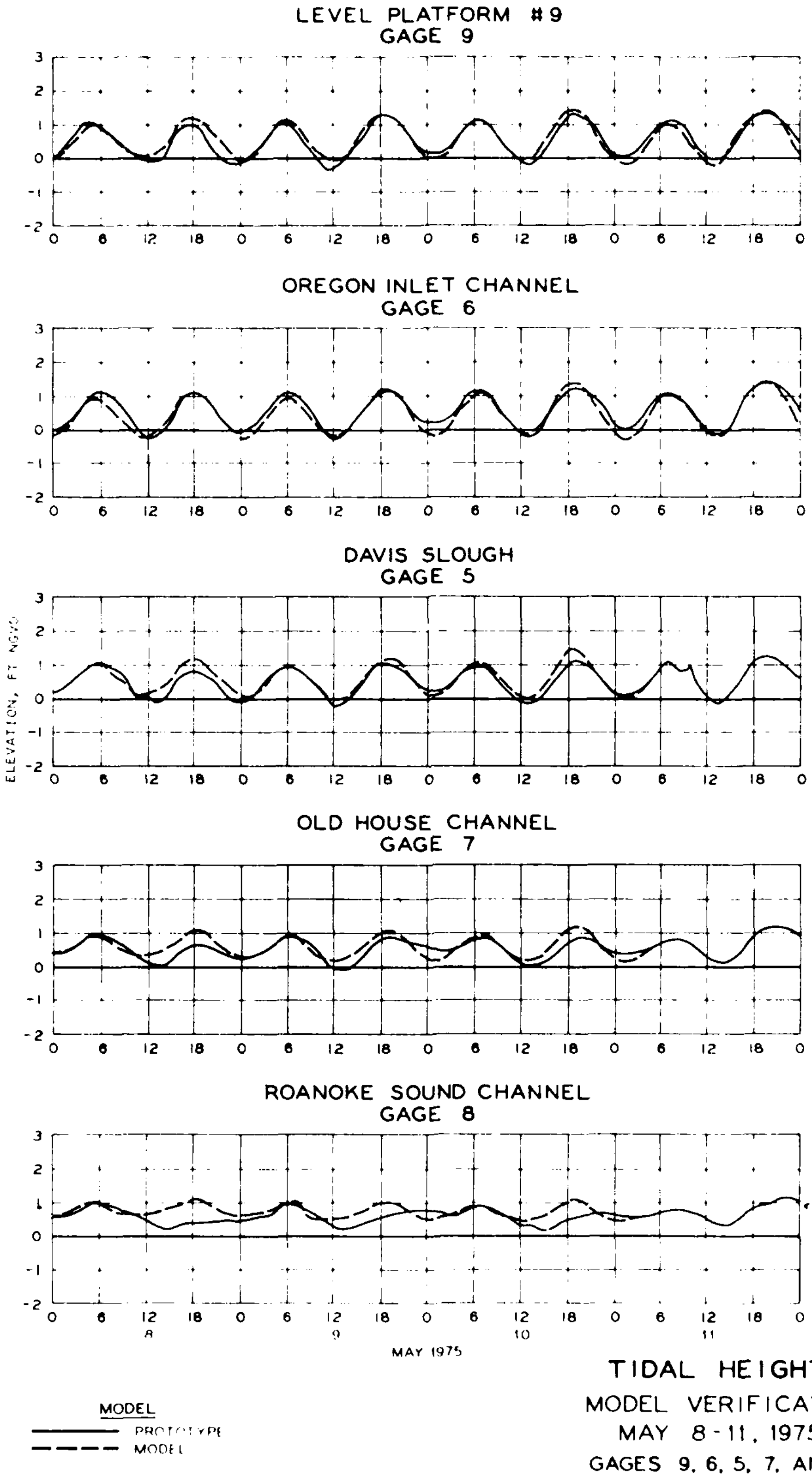


CURRENT VELOCITIES
MODEL VERIFICATION
STATION 9

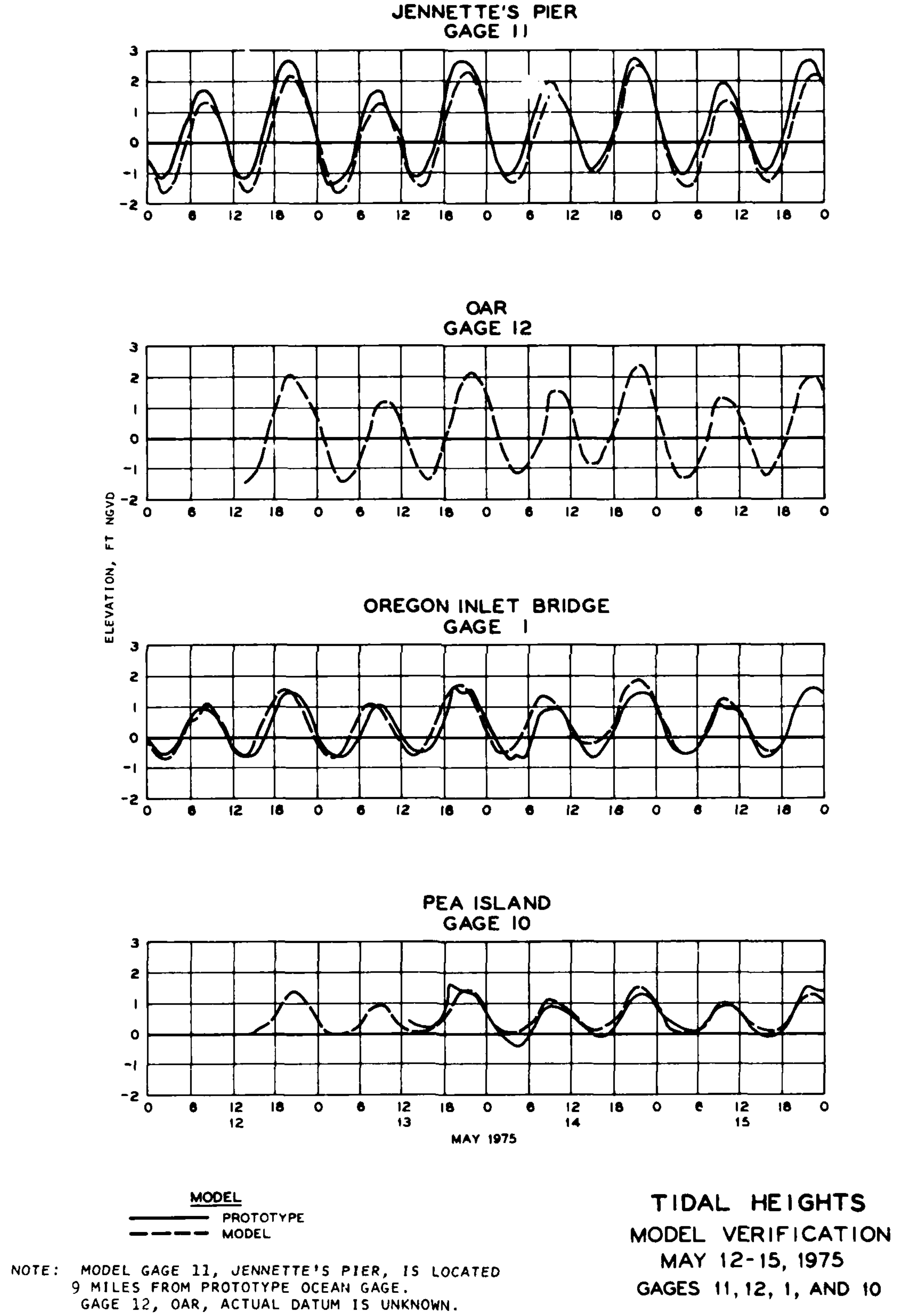


NOTE: MODEL GAGE 11, JENNETTE'S PIER, IS LOCATED 9 MILES FROM PROTOTYPE OCEAN GAGE.
GAGE 12, OAR, ACTUAL DATUM IS UNKNOWN.

TIDAL HEIGHTS
MODEL VERIFICATION
MAY 8-11, 1975
GAGES 11, 12, 1, AND 10

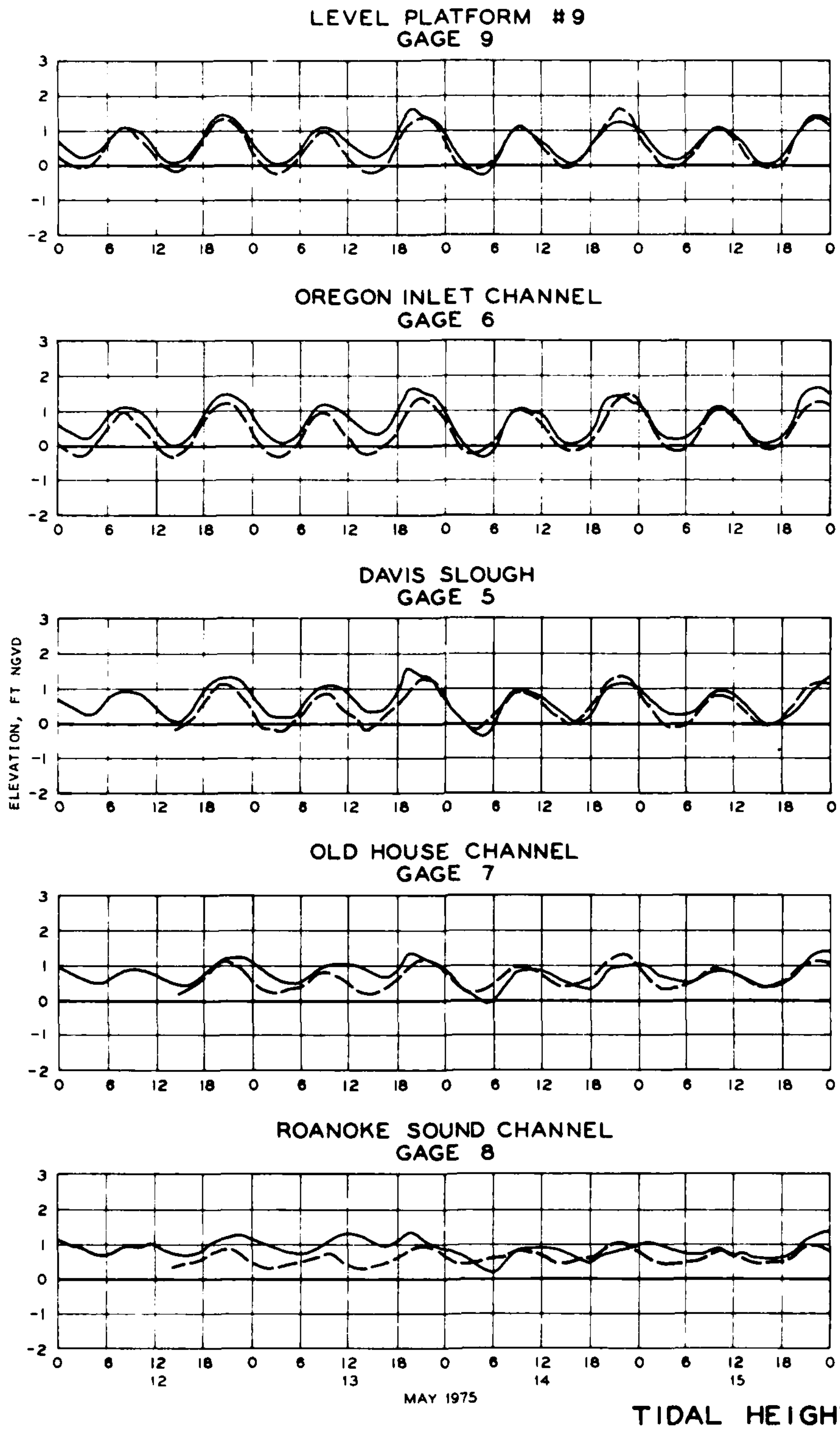


TIDAL HEIGHTS
MODEL VERIFICATION
MAY 8-11, 1975
GAGES 9, 6, 5, 7, AND 8



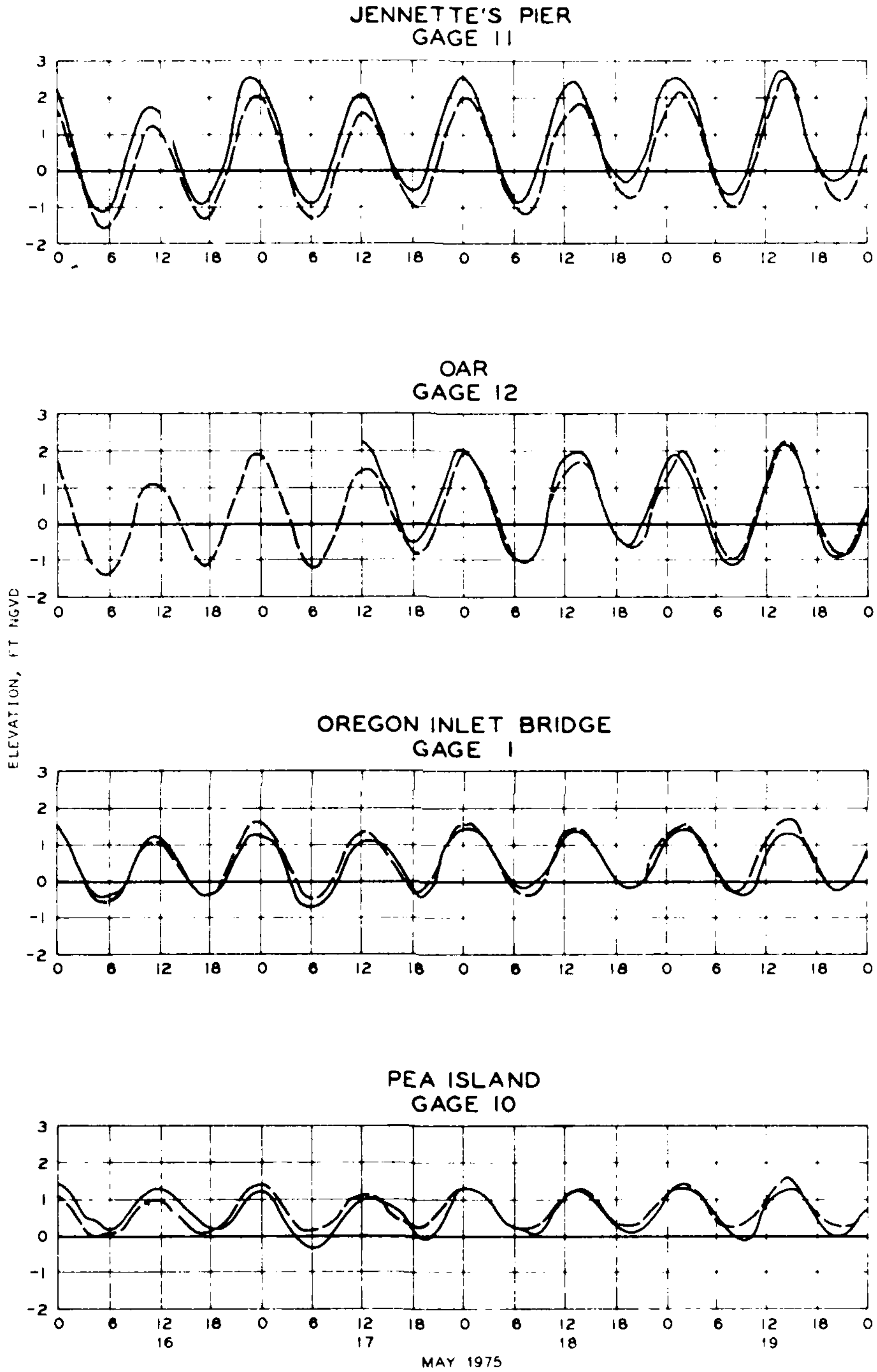
TIDAL HEIGHTS
MODEL VERIFICATION
MAY 12-15, 1975
GAGES 11, 12, 1, AND 10

PLATE 12



MODEL
PROTOTYPE
MODEL

TIDAL HEIGHTS
MODEL VERIFICATION
MAY 12-15, 1975
GAGES 9, 6, 5, 7, AND 8



MODEL

——— PROTOTYPE

– – – MODEL

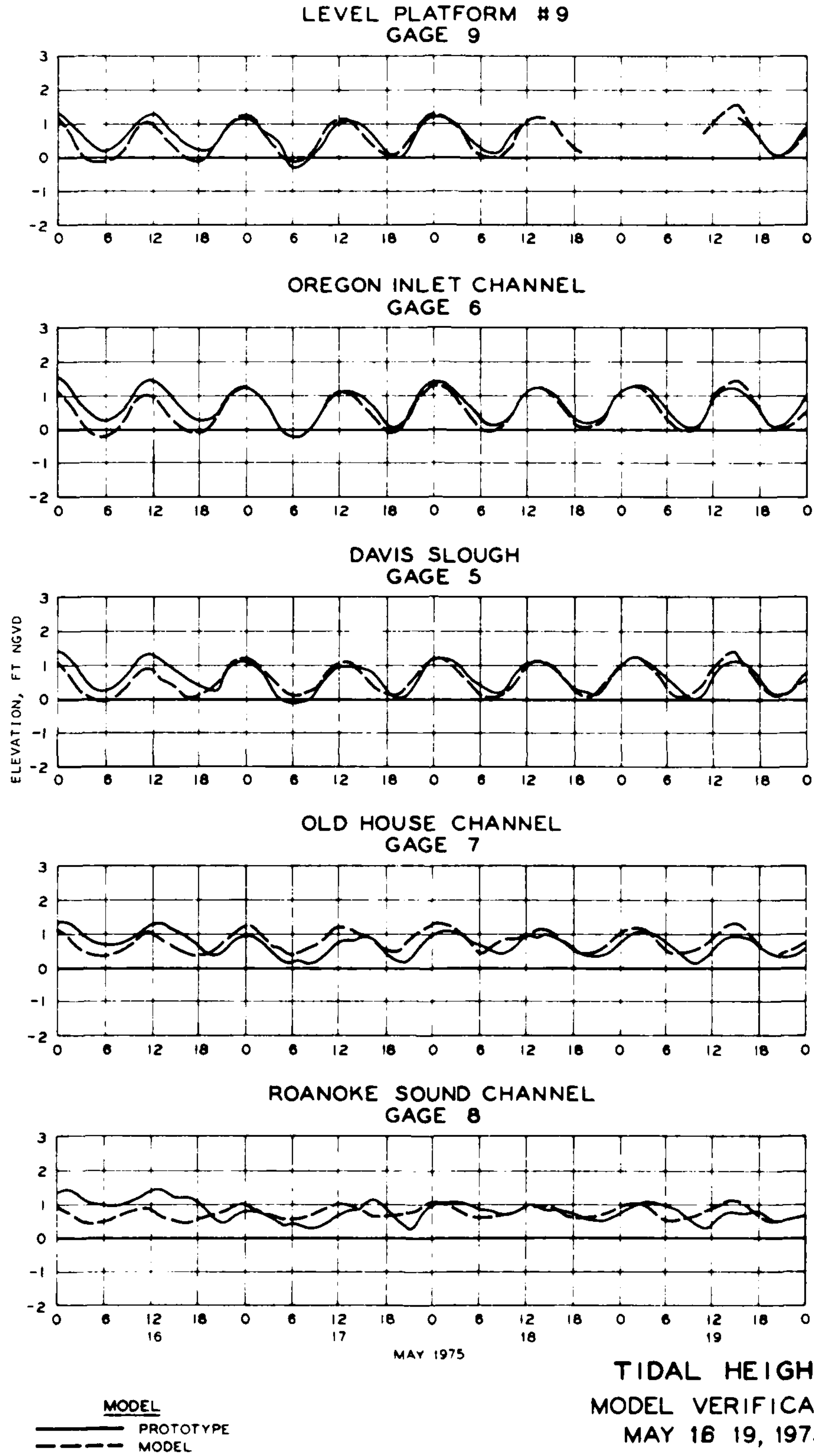
NOTE: MODEL GAGE 11, JENNETTE'S PIER, IS LOCATED 9 MILES FROM PROTOTYPE OCEAN GAGE. GAGE 12, OAR, ACTUAL DATUM IS UNKNOWN.

TIDAL HEIGHTS

MODEL VERIFICATION

MAY 16-19, 1975

GAGES 11, 12, 1, AND 10

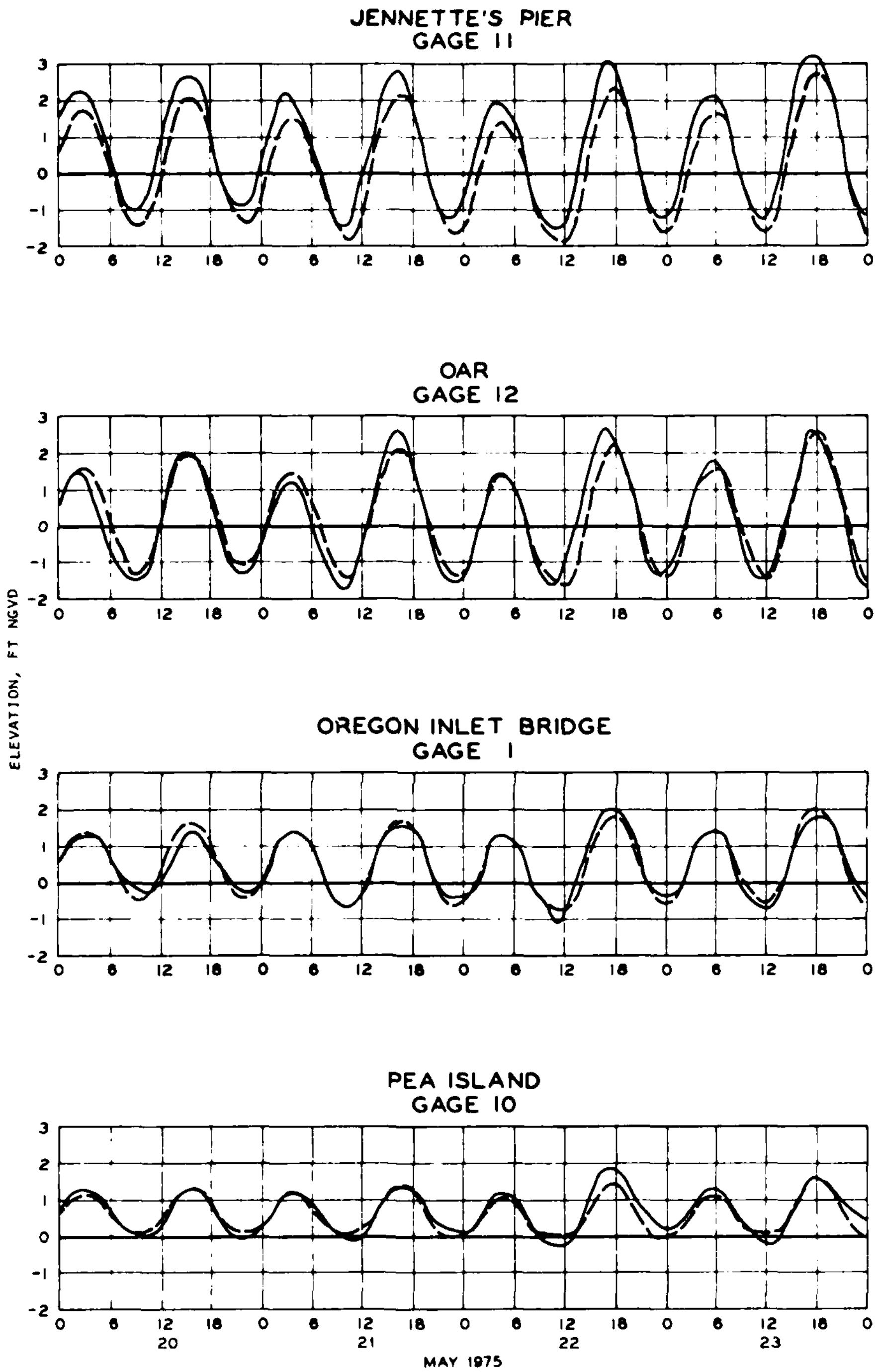


TIDAL HEIGHTS

MODEL VERIFICATION

MAY 16 19, 1975

GAGES 9, 6, 5, 7, AND 8

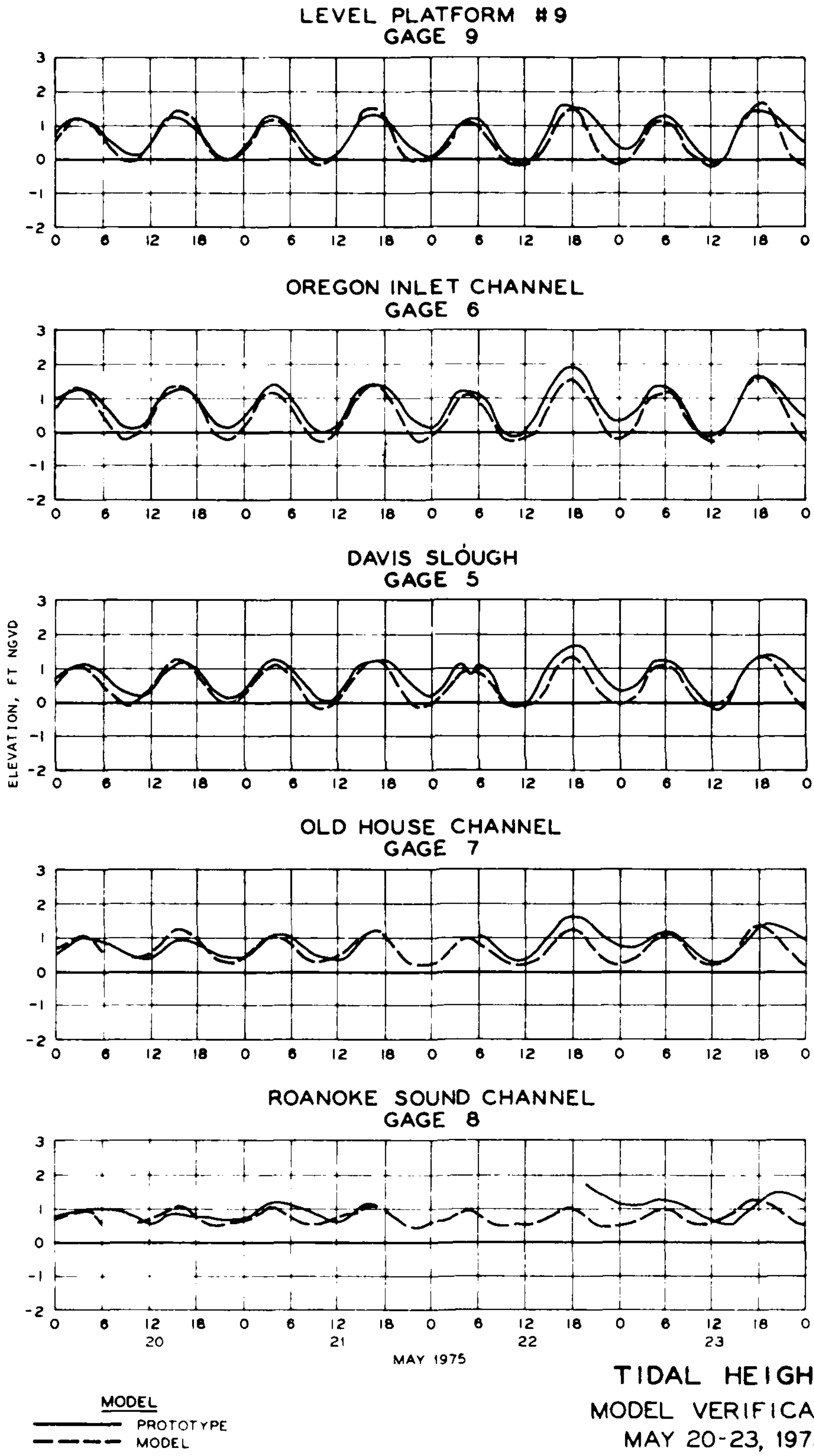


MODEL

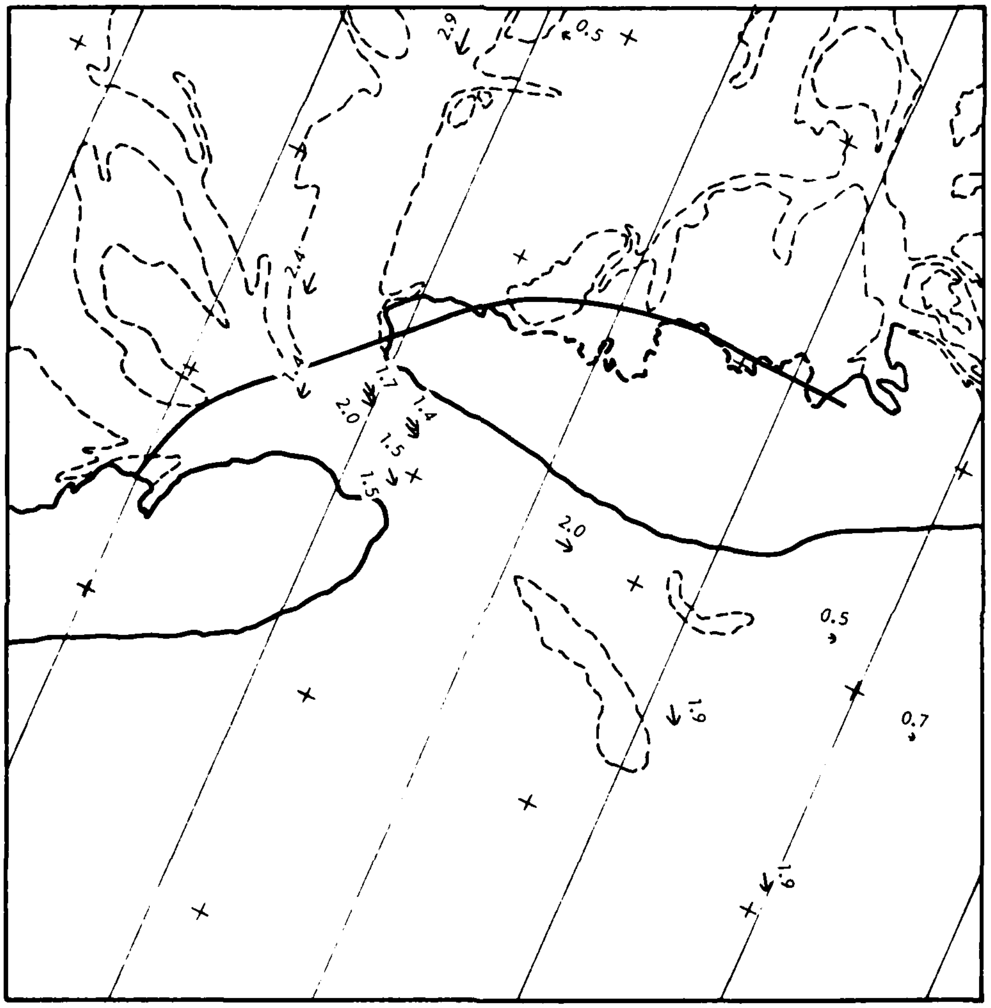
——— PROTOTYPE
– – – MODEL

NOTE: MODEL GAGE 11, JENNETTE'S PIER, IS LOCATED 9 MILES FROM PROTOTYPE OCEAN GAGE. GAGE 12, OAR, ACTUAL DATUM IS UNKNOWN.

TIDAL HEIGHTS
MODEL VERIFICATION
MAY 20-23, 1975
GAGES 11, 12, 1, AND 10



TIDAL HEIGHTS
MODEL VERIFICATION
MAY 20-23, 1975
GAGES 9, 6, 5, 7, AND 8



LEGEND

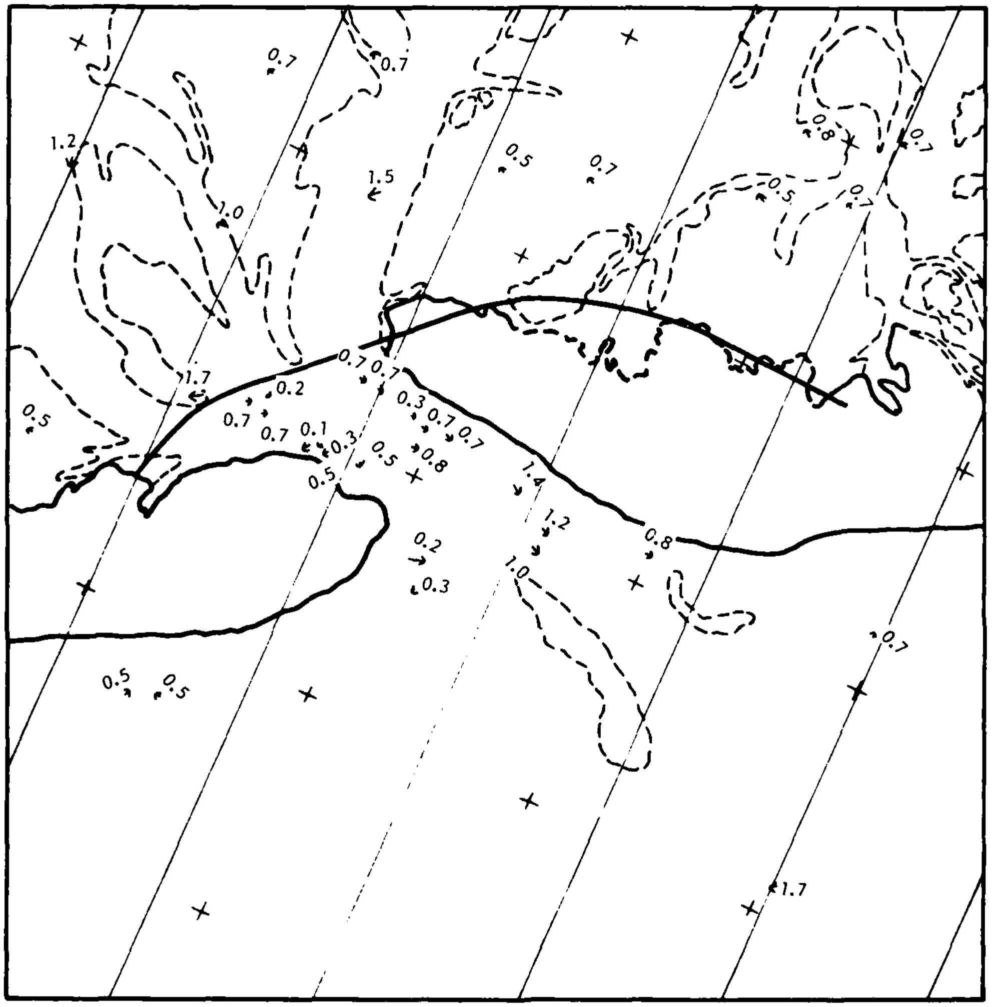
——— HIGH-WATER LINE

– – – – LOW-WATER LINE

0.5 → CURRENT DIRECTION AND SPEED

PROTOTYPE SURFACE CURRENTS

MAY 20 AT 11.5 HR

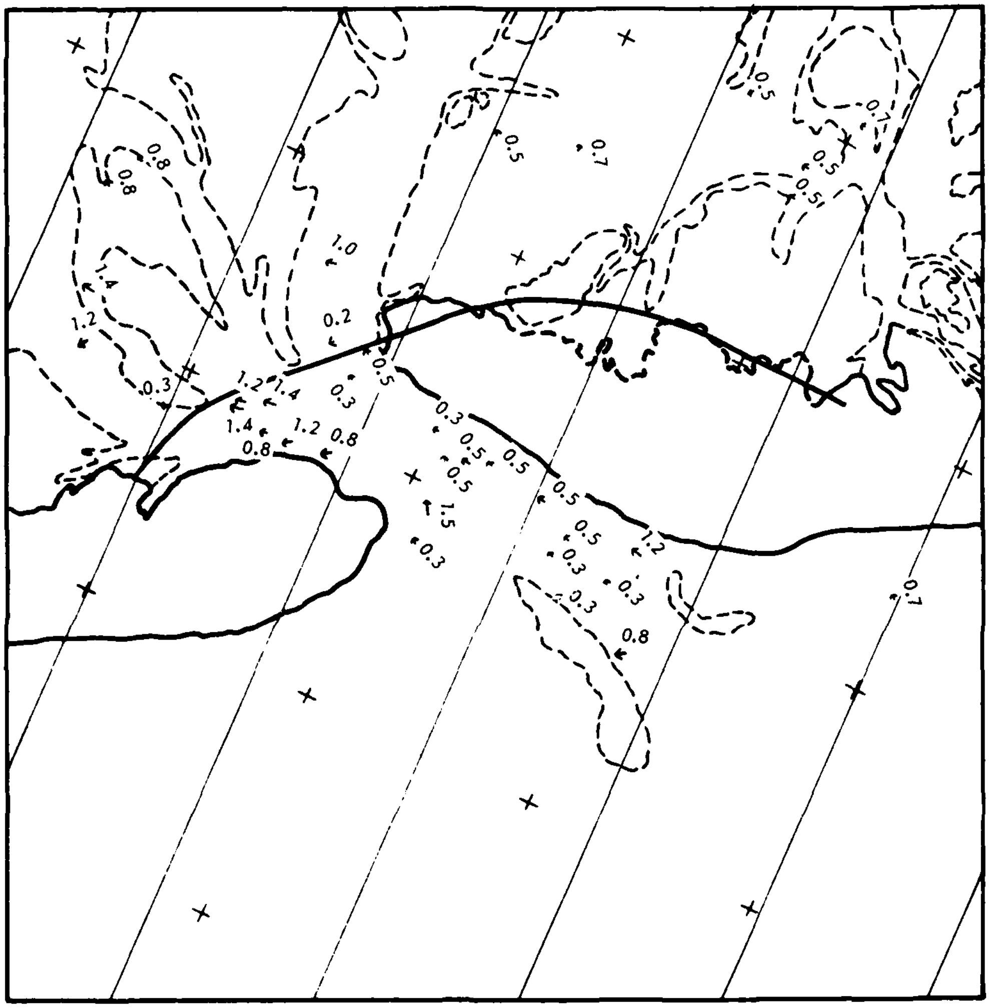


LEGEND

HIGH-WATER LINE
LOW-WATER LINE
CURRENT DIRECTION AND SPEED

PROTOTYPE SURFACE CURRENTS

MAY 20 AT 12.0 HR

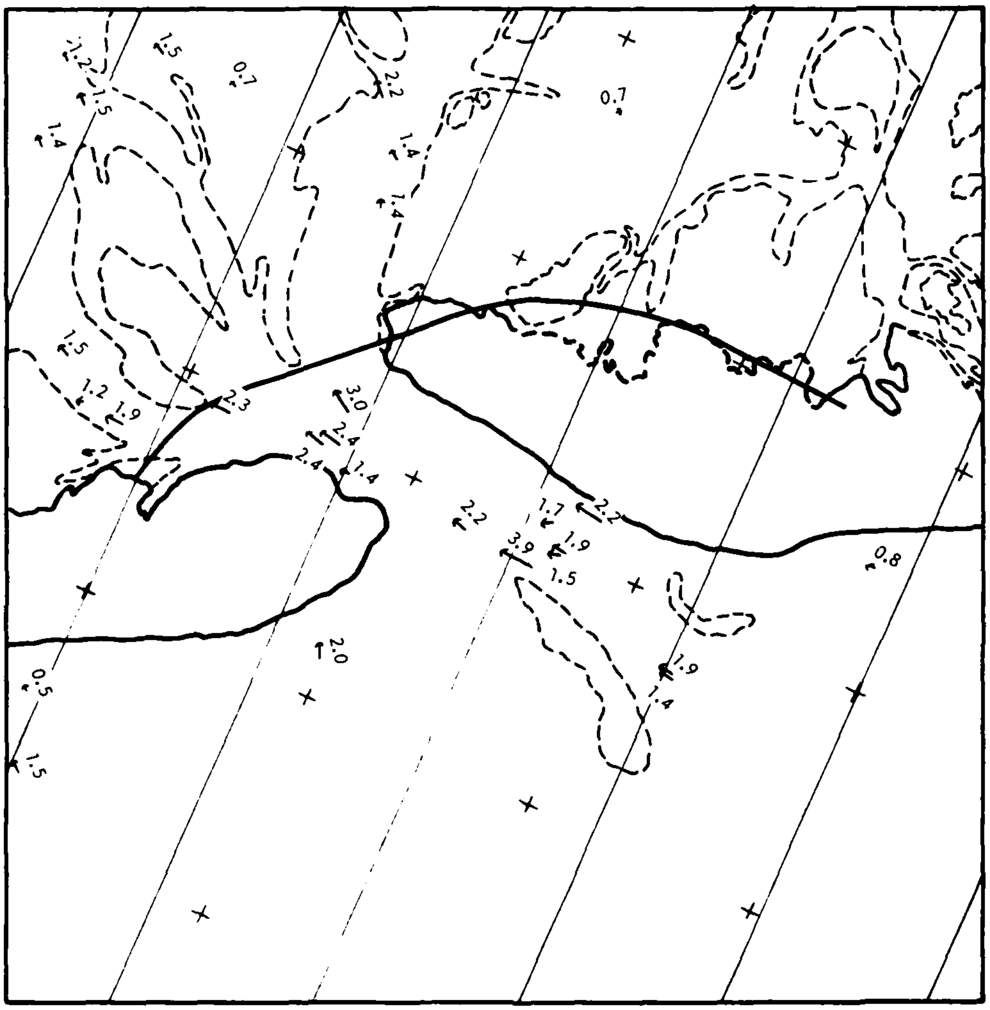


LEGEND

HIGH-WATER LINE
LOW-WATER LINE
0.5 CURRENT DIRECTION AND SPEED

PROTOTYPE SURFACE CURRENTS

MAY 20 AT 12.5 HR



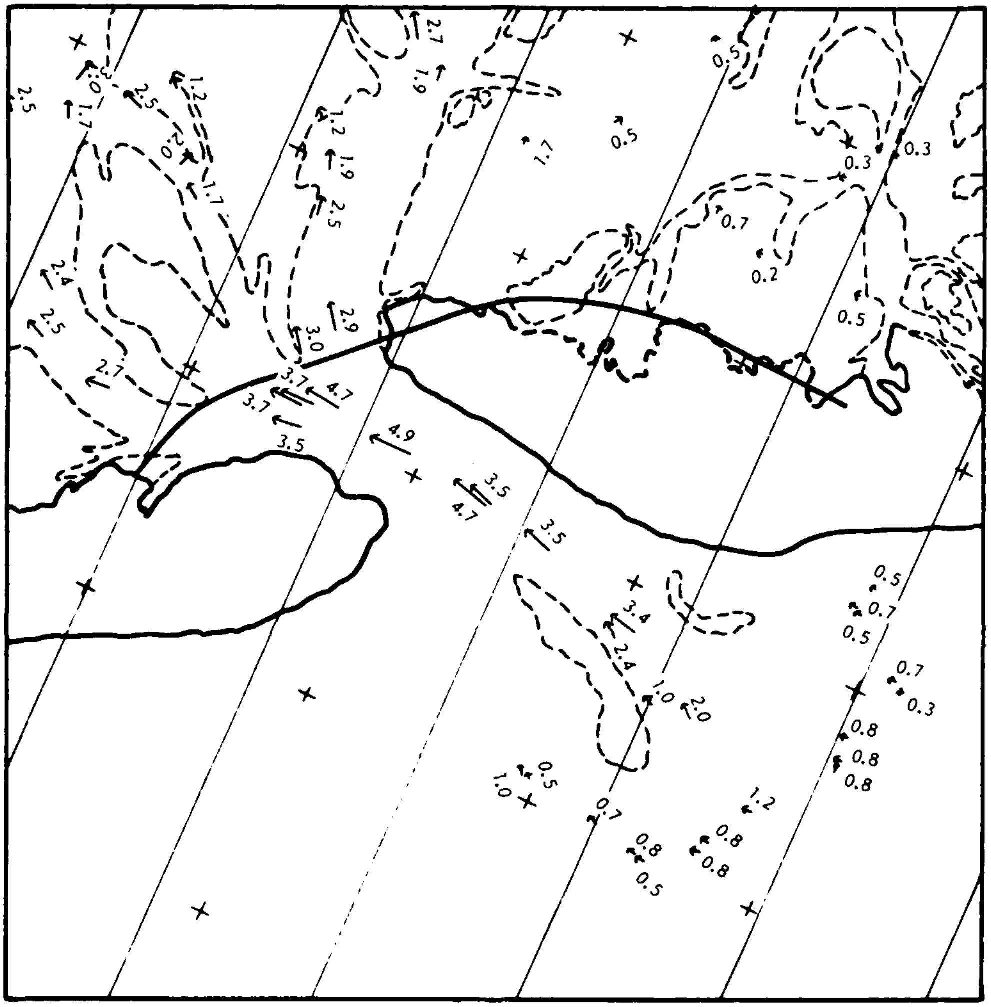
LEGEND

——— HIGH-WATER LINE
- - - - LOW-WATER LINE
$\xrightarrow{0.5}$ CURRECT DIRECTION AND SPEED

PROTOTYPE SURFACE CURRENTS

MAY 20 AT 13.0 HR

PLATE 21



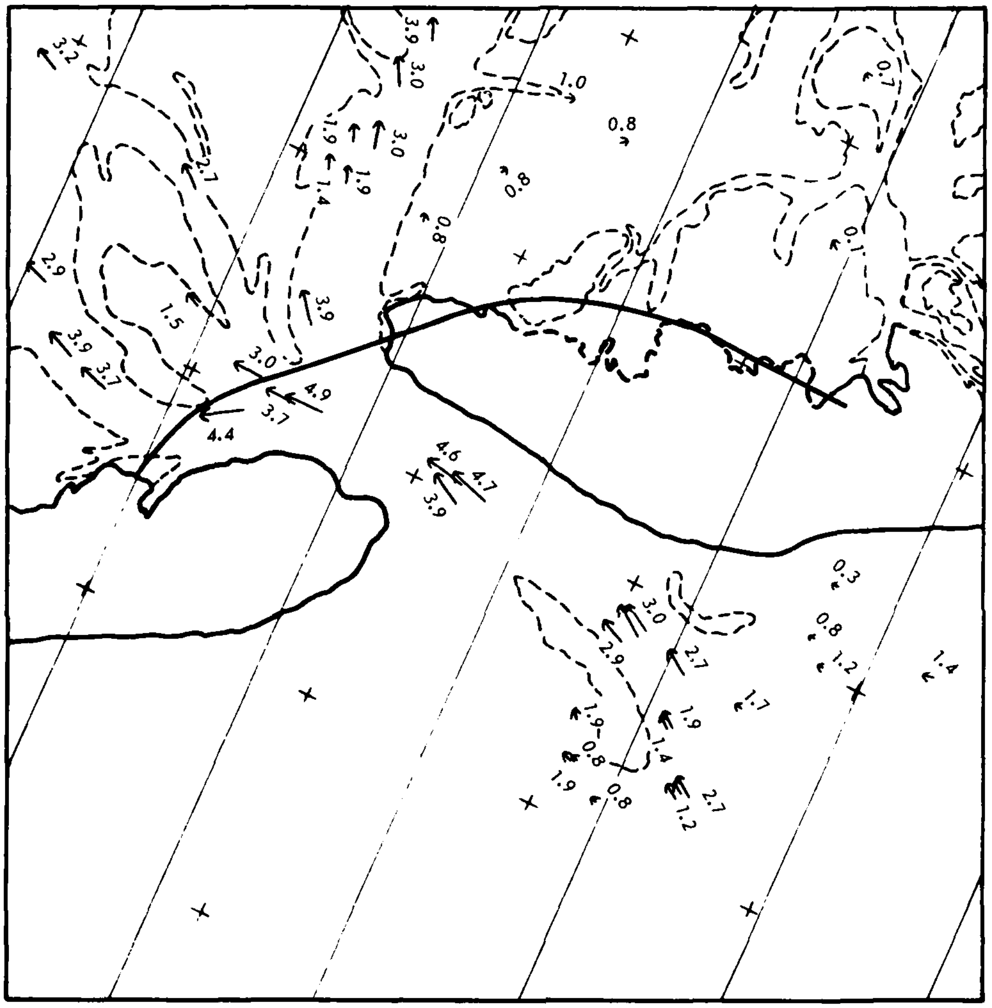
LEGEND

- HIGH-WATER LINE
- LOW-WATER LINE
- 0.5 CURRENT DIRECTION AND SPEED

PROTOTYPE SURFACE CURRENTS

MAY 20 AT 13.5 HR

PLATE 22



LEGEND

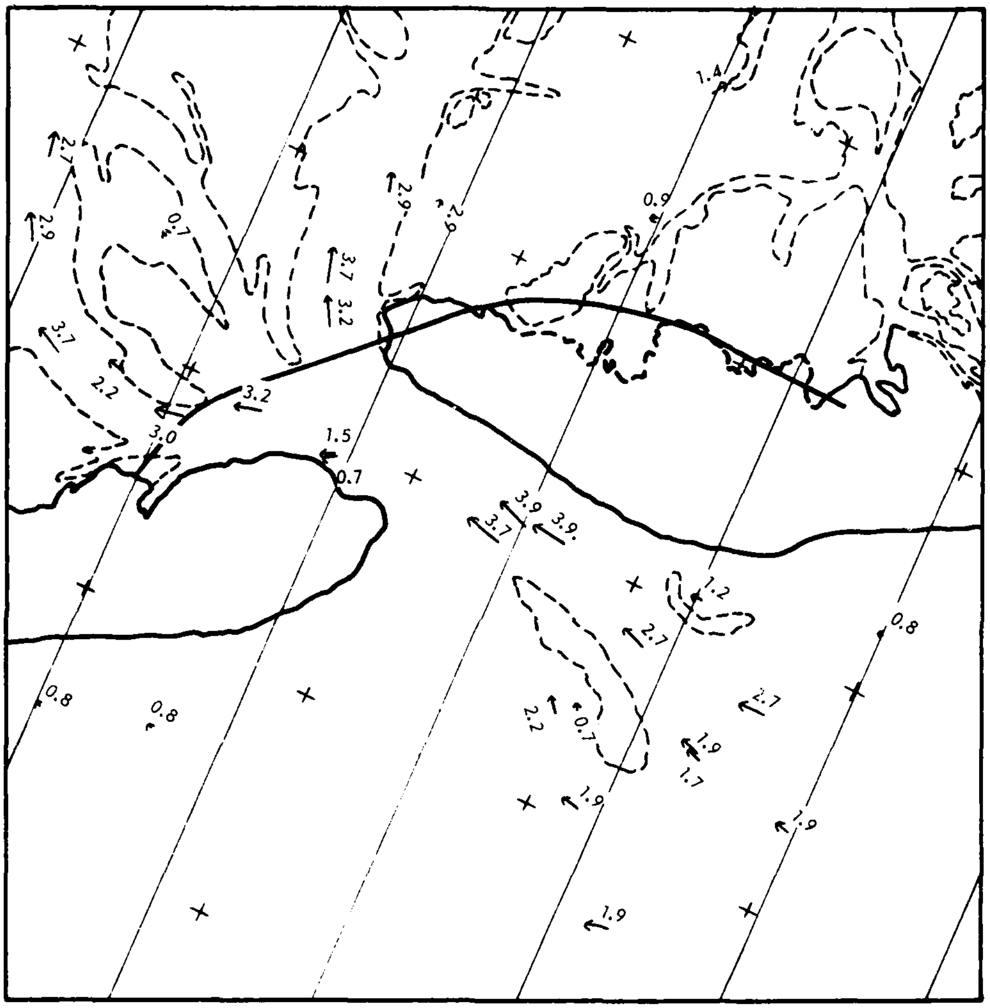
HIGH-WATER LINE

LOW-WATER LINE

0.5 CURRENT DIRECTION AND SPEED

PROTOTYPE SURFACE CURRENTS

MAY 20 AT 14.0 HR



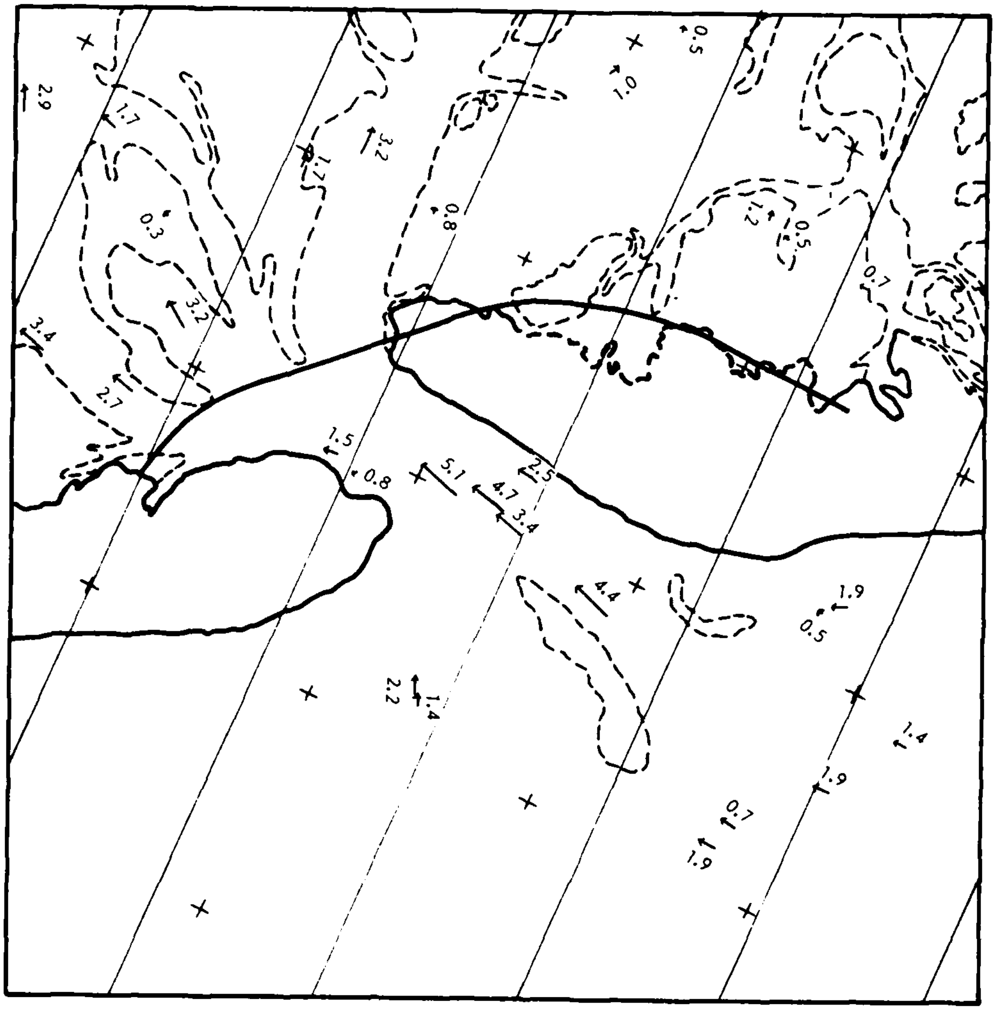
LEGEND

HIGH-WATER LINE
LOW-WATER LINE
0.5 CURRENT DIRECTION AND SPEED

PROTOTYPE SURFACE CURRENTS

MAY 20 AT 14.5 HR

PLATE 24

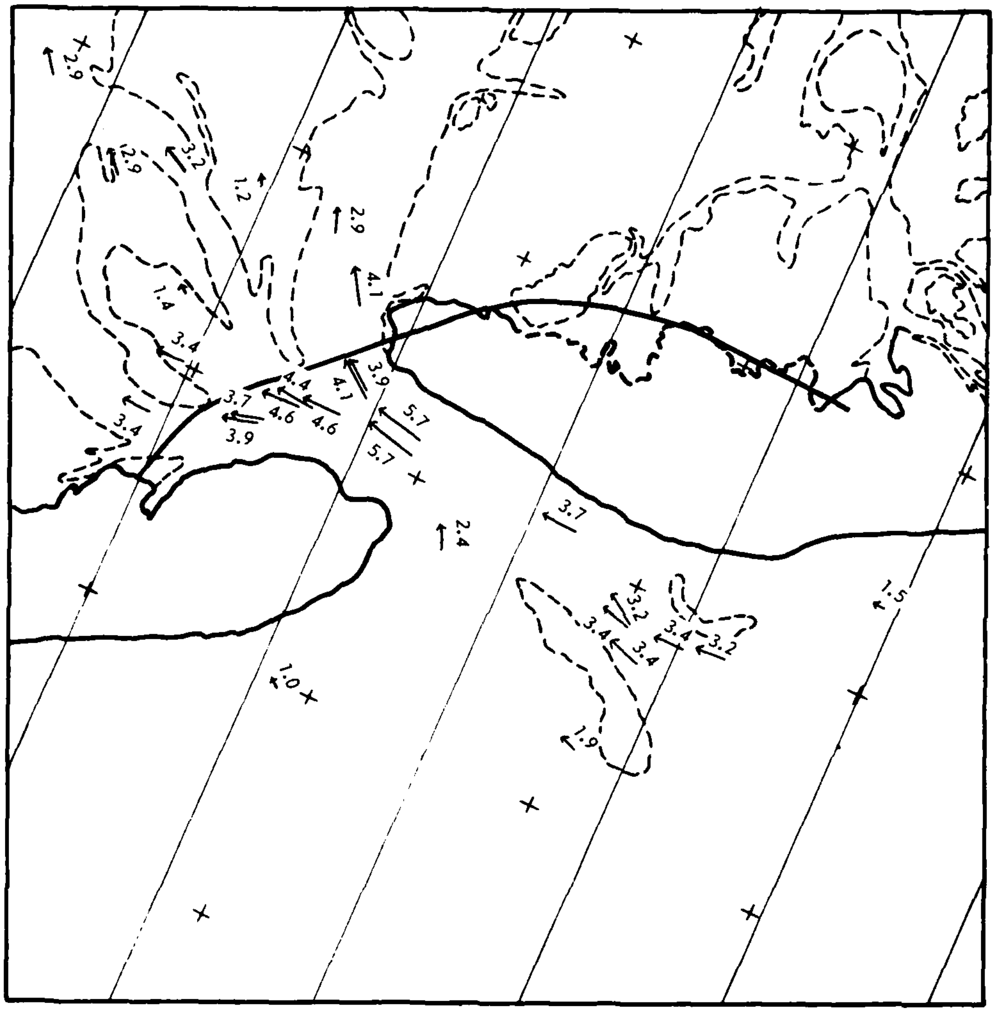


LEGEND

HIGH-WATER LINE
LOW-WATER LINE
0.5 CURRENT DIRECTION AND SPEED

PROTOTYPE SURFACE CURRENTS

MAY 20 AT 15.0 HR



LEGEND

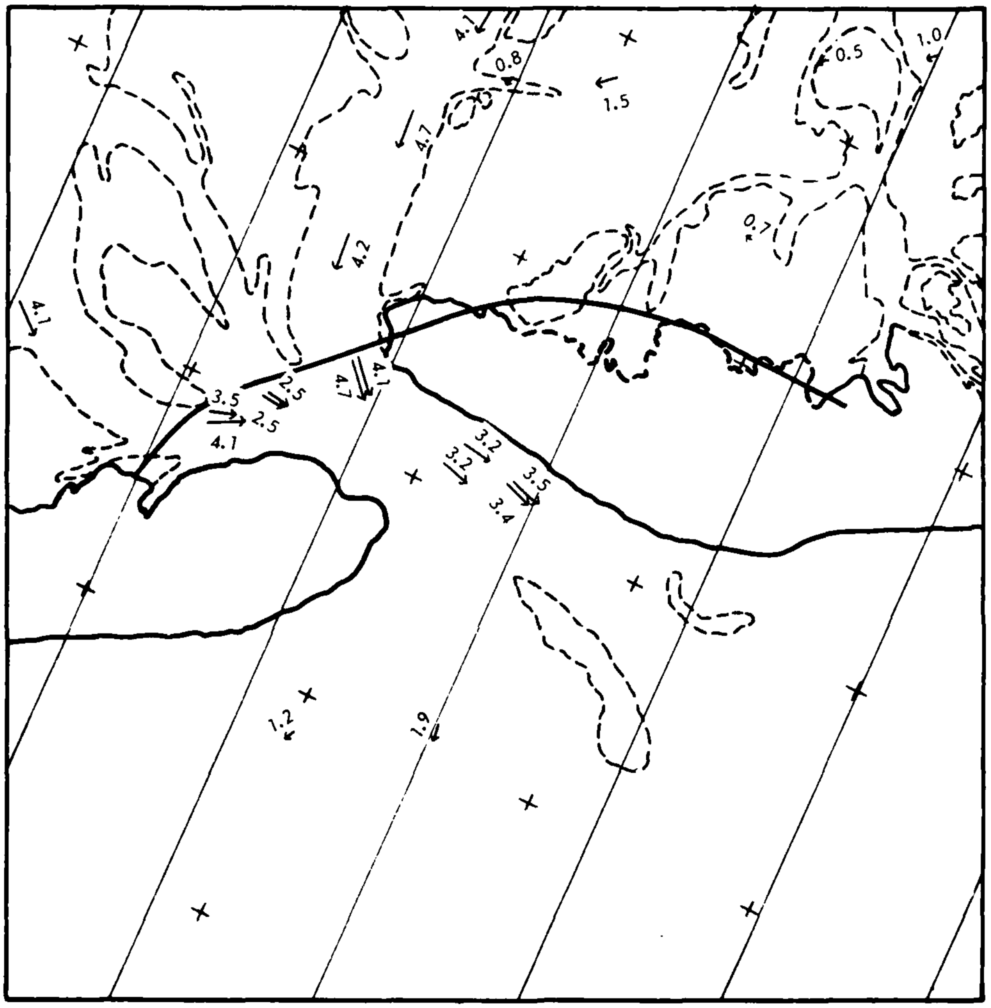
HIGH-WATER LINE

LOW-WATER LINE

0.5 CURRENT DIRECTION AND SPEED

PROTOTYPE SURFACE CURRENTS

MAY 20 AT 15.5 HR

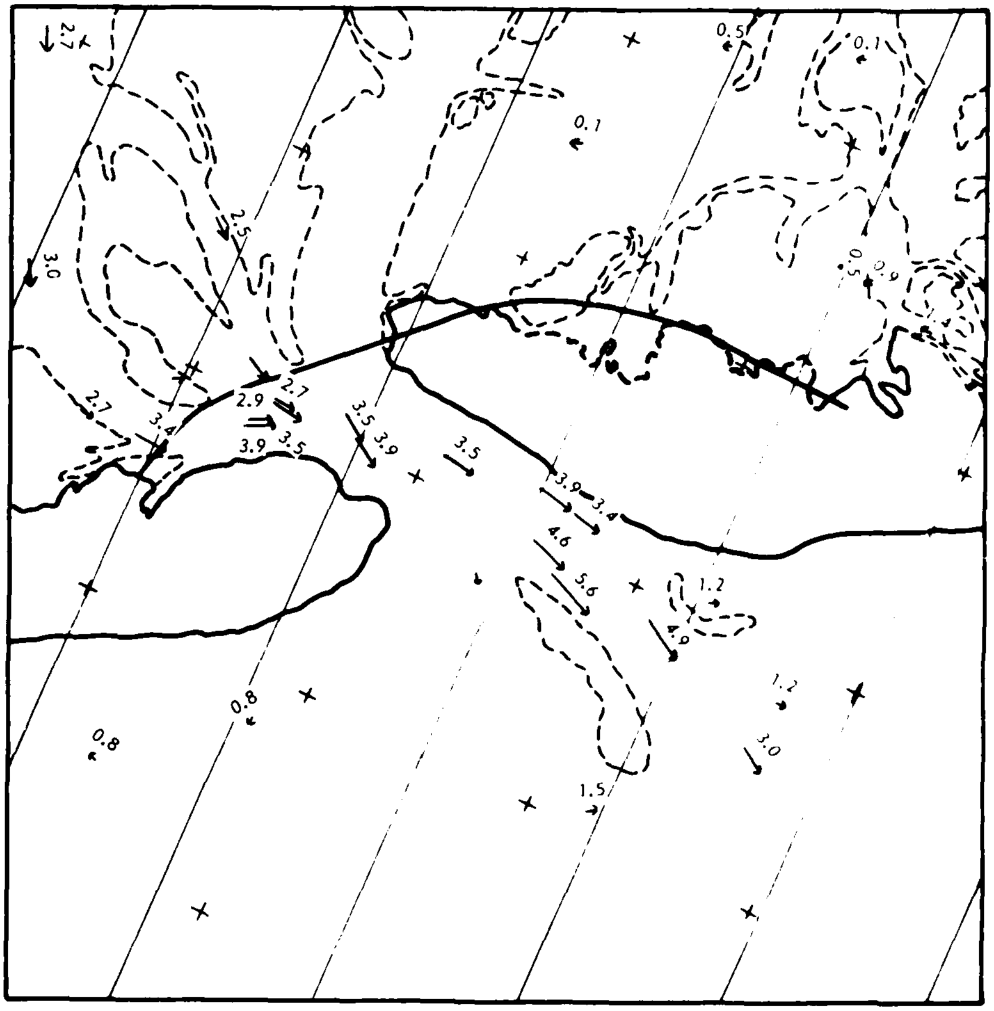


LEGEND

HIGH-WATER LINE
LOW-WATER LINE
0.5 CURRENT DIRECTION AND SPEED

PROTOTYPE SURFACE CURRENTS

MAY 21 AT 9.0 HR



LEGEND

HIGH-WATER LINE

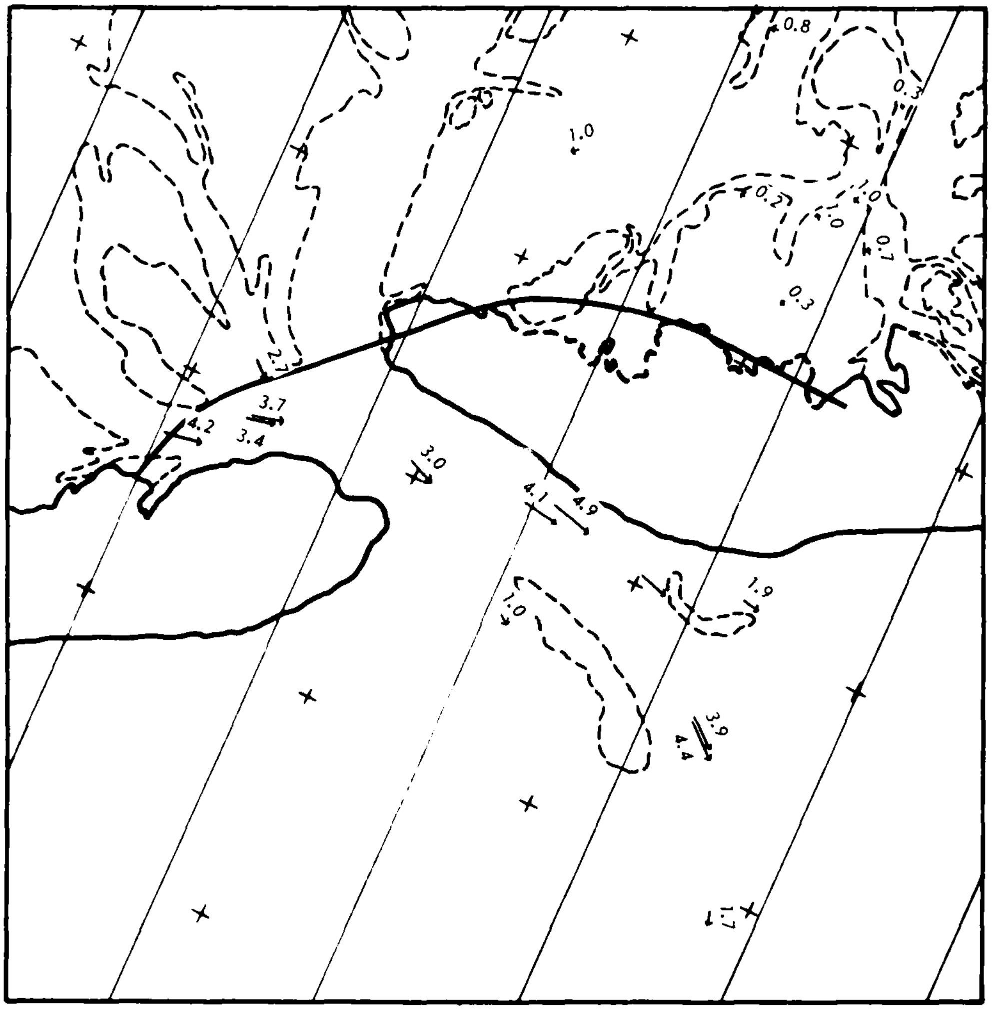
LOW-WATER LINE

0.5 CURRENT DIRECTION AND SPEED

PROTOTYPE SURFACE CURRENTS

MAY 21 AT 9.5 HR

PLATE 28



LEGEND

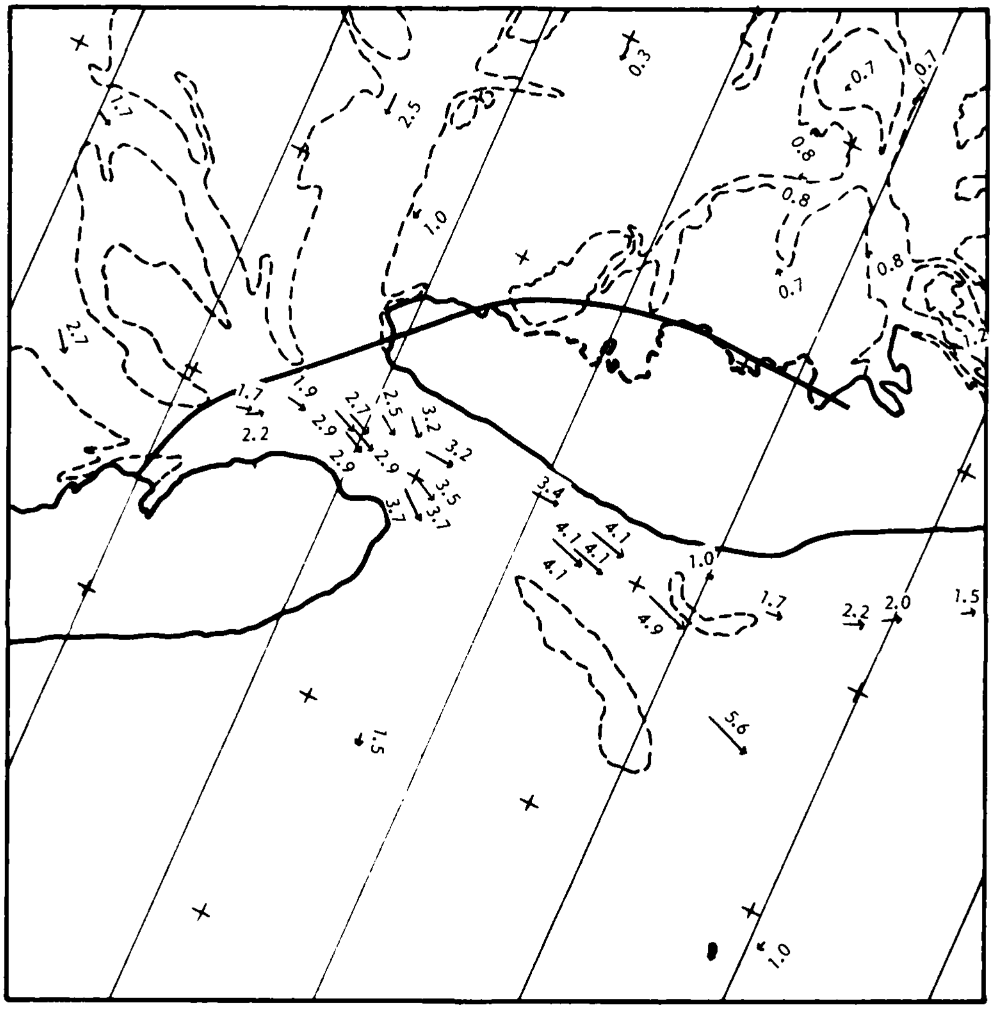
——— HIGH-WATER LINE

- - - - LOW-WATER LINE

$\overset{0.5}{\longrightarrow}$ CURRECT DIRECTION AND SPEED

PROTOTYPE SURFACE CURRENTS

MAY 21 AT 10.0 HR



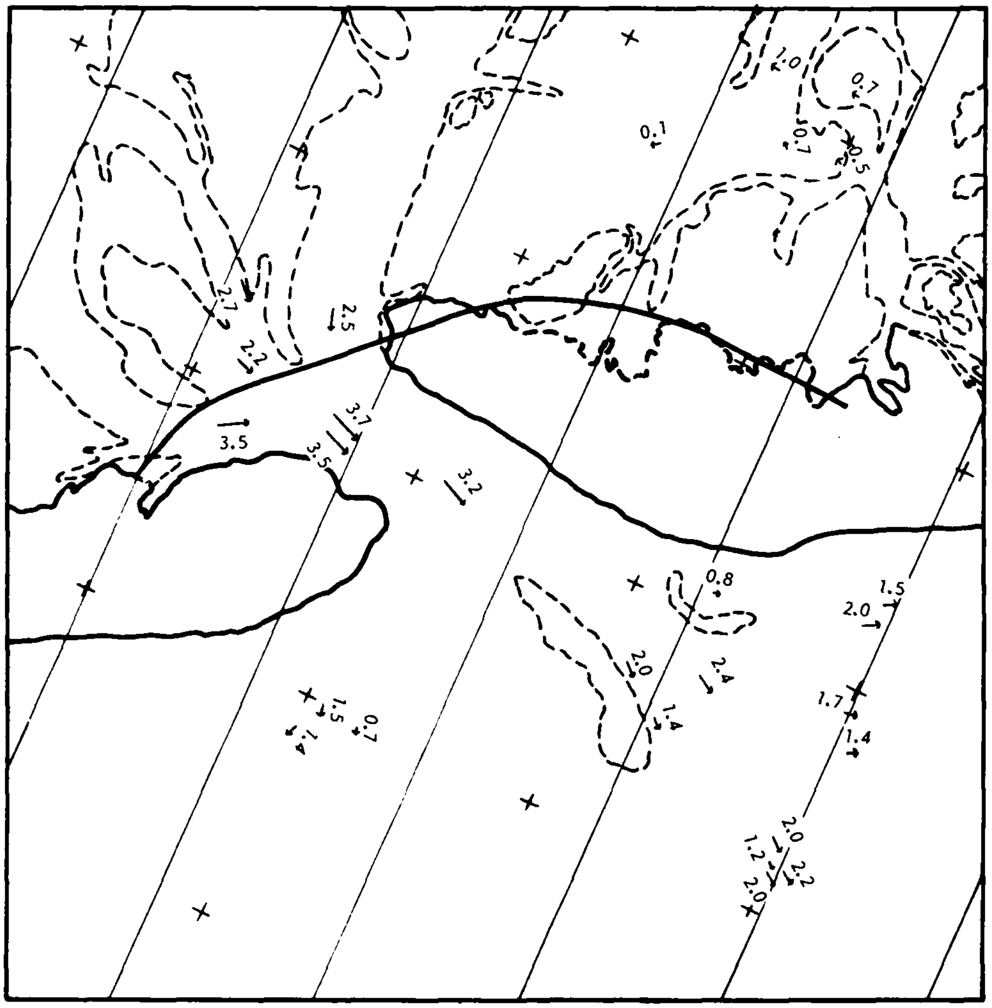
LEGEND

—— HIGH-WATER LINE
- - - - LOW-WATER LINE
$\xrightarrow{0.5}$ CURRENT DIRECTION AND SPEED

PROTOTYPE SURFACE CURRENTS

MAY 21 AT 10.5 HR

PLATE 30



LEGEND

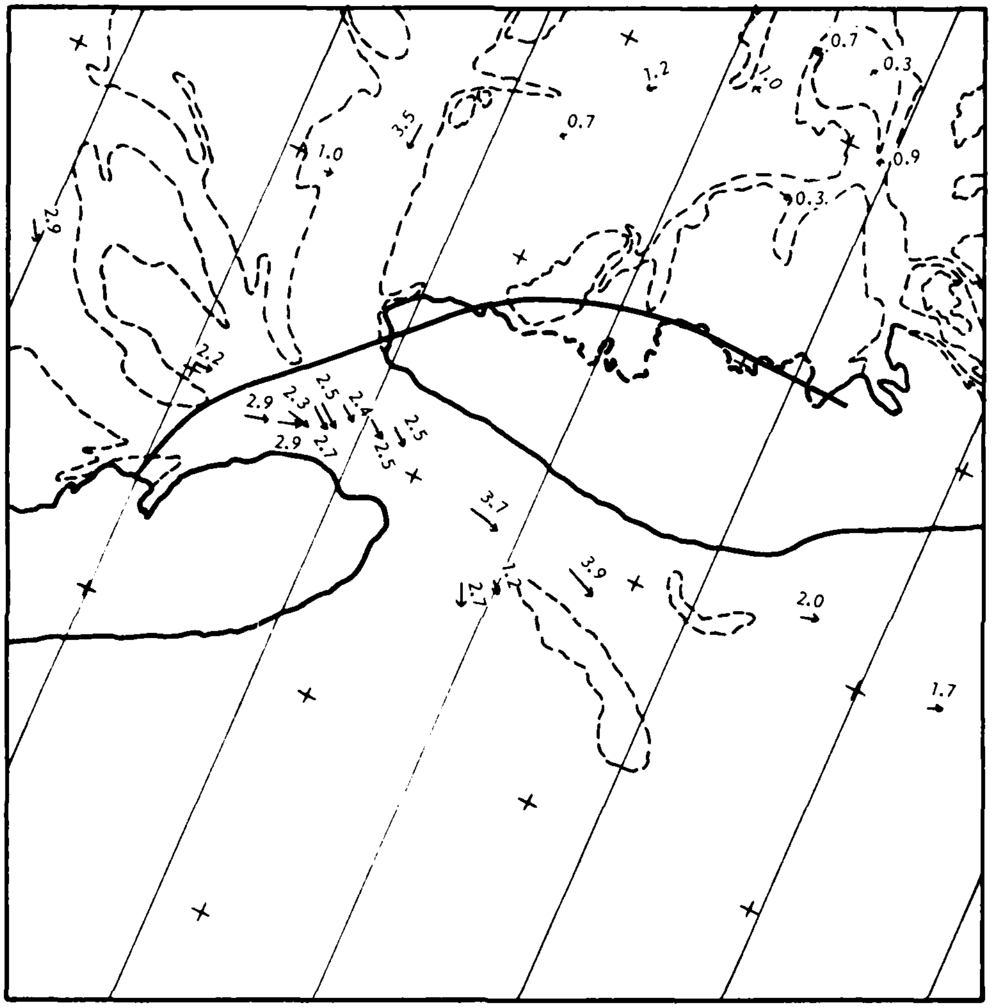
HIGH-WATER LINE

LOW-WATER LINE

0.5 CURRENT DIRECTION AND SPEED

PROTOTYPE SURFACE CURRENTS

MAY 21 AT 11.0 HR

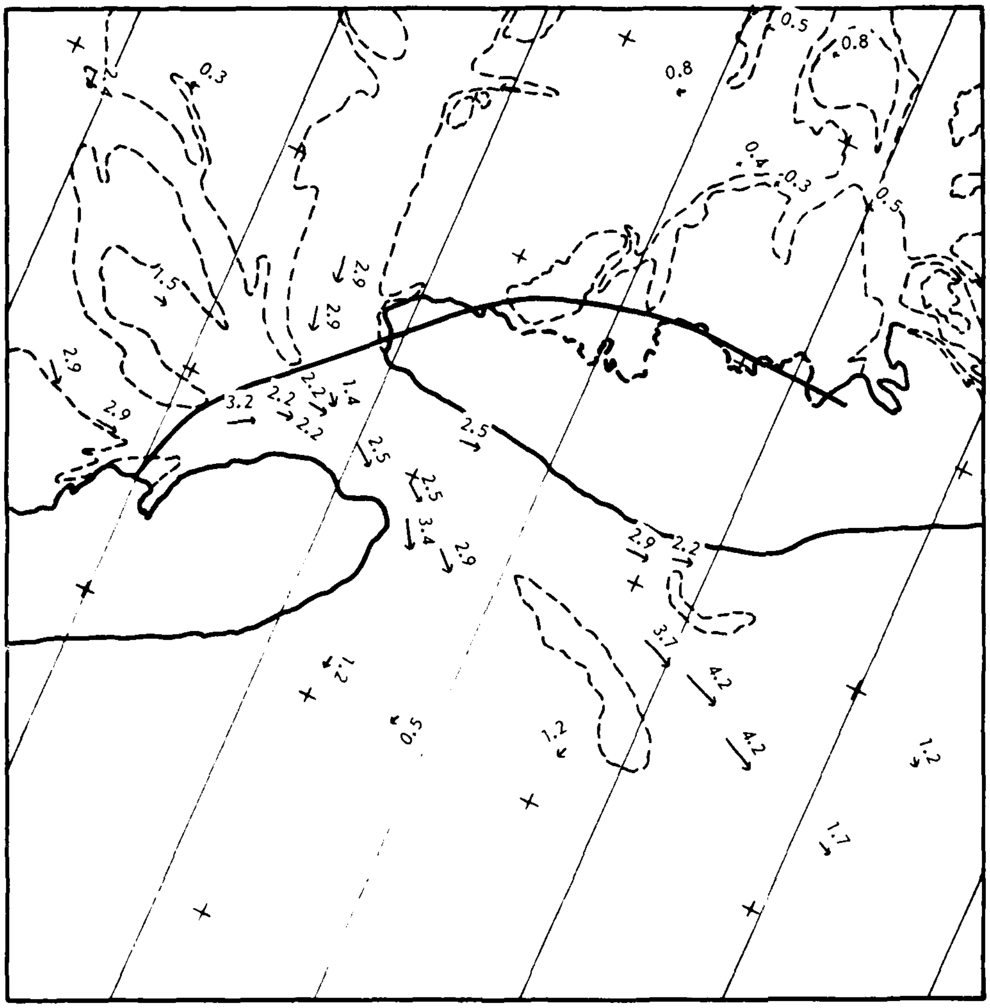


LEGEND

HIGH-WATER LINE
LOW-WATER LINE
0.5 CURRENT DIRECTION AND SPEED

PROTOTYPE SURFACE CURRENTS

MAY 21 AT 11.5 HR



LEGEND

HIGH-WATER LINE
LOW-WATER LINE
0.5 CURRENT DIRECTION AND SPEED

PROTOTYPE SURFACE CURRENTS

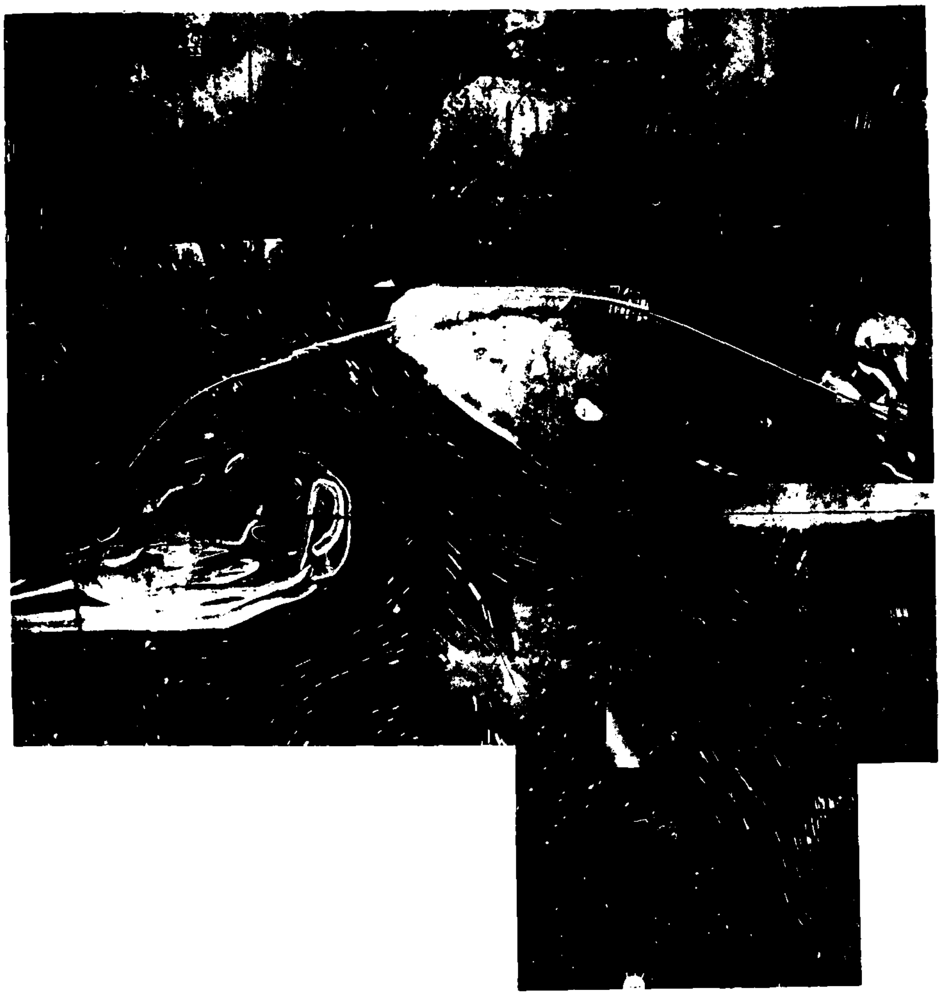
MAY 21 AT 12.0 HR

VELOCITY SCALE

5 0 5 10 15 20

FT/SEC

SURFACE CURRENT PHOTOGRAPHS
MODEL VERIFICATION
MAY 20 AT 11.5 HR



VELOCITY SCALE

5 0 5 10 15 20

FT/SEC

SURFACE CURRENT PHOTOGRAPHS
MODEL VERIFICATION
MAY 20 AT 12.0 HR

VELOCITY SCALE
5 0 5 10 15 20
FT/SEC

SURFACE CURRENT PHOTOGRAPHS
MODEL VERIFICATION
MAY 20 AT 12.5 HR

PLATE 36

SURFACE CURRENT PHOTOGRAPHS
MODEL VERIFICATION
MAY 20 AT 13.0 HR

VELOCITY SCALE
5 0 5 10 15 20
FT/SEC

SURFACE CURRENT PHOTOGRAPHS
MODEL VERIFICATION
MAY 20 AT 13.5 HR

PLATE 38

VELOCITY SCALE

5 0 5 10 15 20

FT/SEC

SURFACE CURRENT PHOTOGRAPHS

MODEL VERIFICATION

MAY 20 AT 14.0 HR

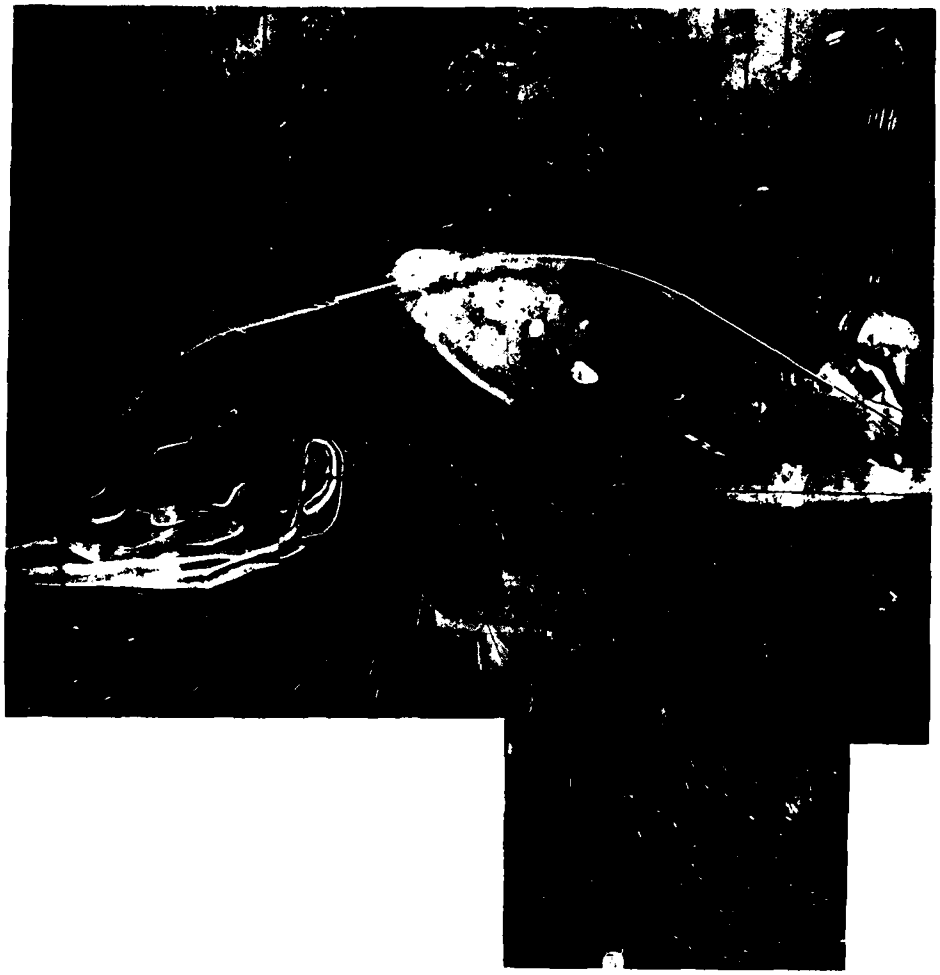
PLATE 39

VELOCITY SCALE

5 0 5 10 15 20

FT/SEC

SURFACE CURRENT PHOTOGRAPHS
MODEL VERIFICATION
MAY 20 AT 14.5 HR



VELOCITY SCALE
5 0 5 10 15 20
FT/SEC

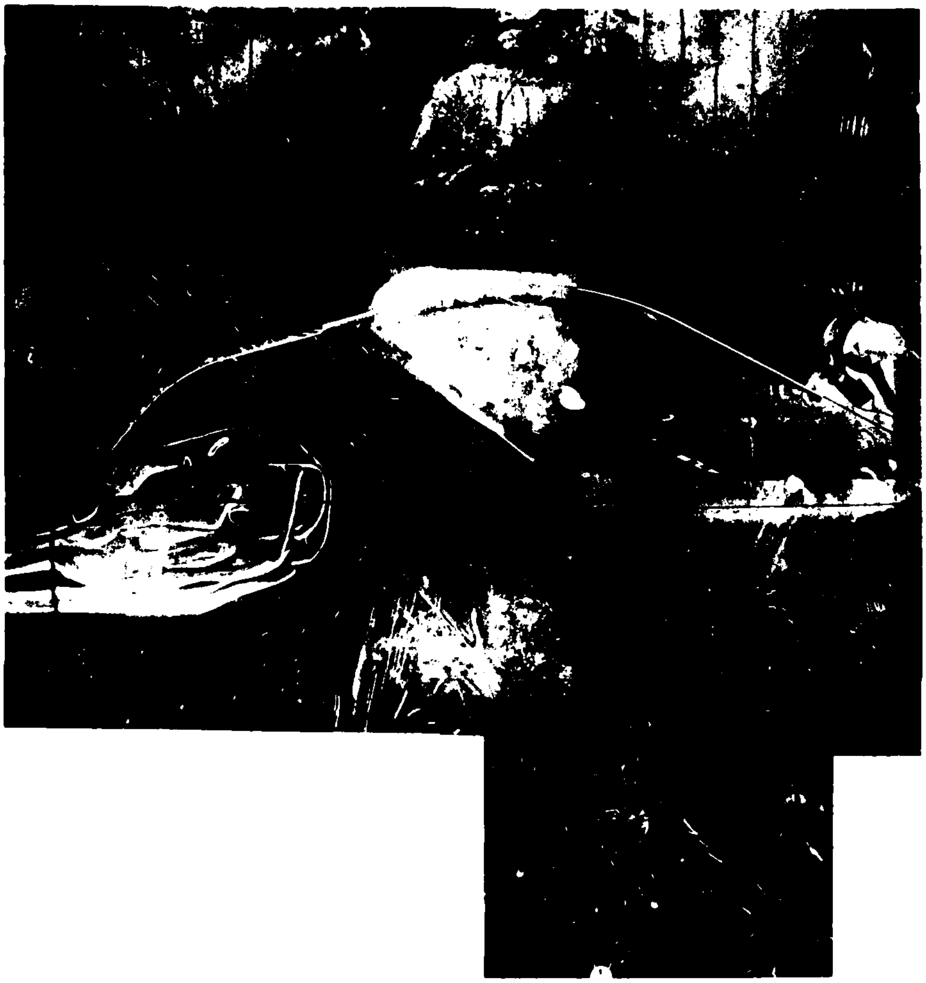
SURFACE CURRENT PHOTOGRAPHS
MODEL VERIFICATION
MAY 20 AT 15.0 HR

VELOCITY SCALE
5 0 5 10 15 20
FT/SEC

SURFACE CURRENT PHOTOGRAPHS
MODEL VERIFICATION
MAY 20 AT 155 HR

PLATE 42

SURFACE CURRENT PHOTOGRAPHS
MODEL VERIFICATION
MAY 21 AT 9.0 HR



VELOCITY SCALE

5 0 5 10 15 20

FT/SEC

SURFACE CURRENT PHOTOGRAPHS
MODEL VERIFICATION
MAY 21 AT 9.5 HR

VELOCITY SCALE

5 0 5 10 15 20

FT/SEC

SURFACE CURRENT PHOTOGRAPHS
MODEL VERIFICATION
MAY 21 AT 10.0 HR

SURFACE CURRENT PHOTOGRAPHS
MODEL VERIFICATION
MAY 21 AT 10.5 HR

PLATE 46

VELOCITY SCALE

5 0 5 10 15 20

FT/SEC

SURFACE CURRENT PHOTOGRAPHS
MODEL VERIFICATION
MAY 21 AT 11.0 HR

VELOCITY SCALE

5 0 5 10 15 20

FT / SEC

SURFACE CURRENT PHOTOGRAPHS
MODEL VERIFICATION
MAY 21 AT 11.5 HR

VELOCITY SCALE

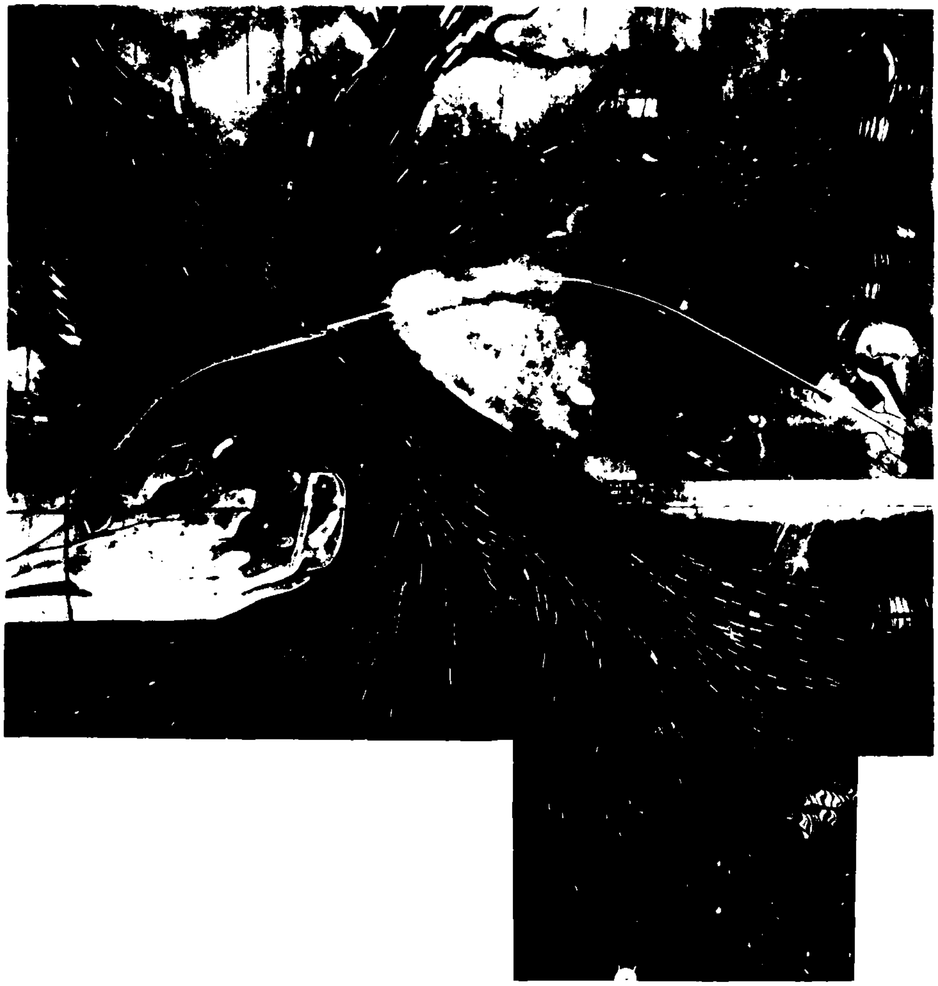
5 0 5 10 15 20

FT/SEC

SURFACE CURRENT PHOTOGRAPHS
MODEL VERIFICATION
MAY 21 AT 12.0 HR

VELOCITY SCALE
5 0 5 10 15 20
FT/SEC

SURFACE CURRENT
PHOTOGRAPHS
BASE TEST
TIME-STEP 1
STRENGTH OF EBB



VELOCITY SCALE

5 0 5 10 15 20

FT/SEC

SURFACE CURRENT
PHOTOGRAPHS

BASE TEST

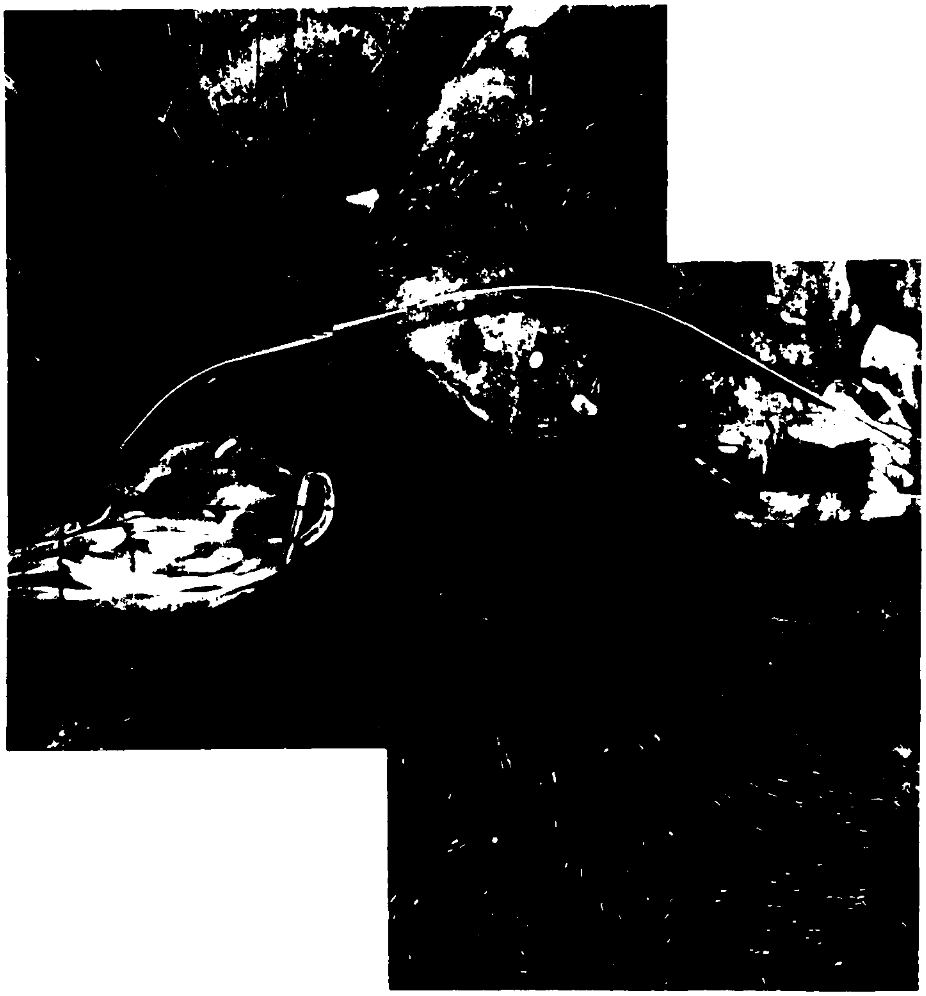
TIME-STEP 16
STRENGTH OF FLOOD

VELOCITY SCALE

10 0 10 20 30 40

FT/SEC

SURFACE CURRENT PHOTOGRAPHS
SIMULATED STORM SURGE OF
12 SEPTEMBER 1960
BASE TEST



SURFACE CURRENT PHOTOGRAPHS
SIMULATED STORM SURGE OF
7 MARCH 1962
BASE TEST

VELOCITY SCALE
5 0 5 10 15 20
FT/SEC

SURFACE CURRENT
PHOTOGRAPHS
JETTY ALIGNMENT 1, LENGTH 1
TIME-STEP 1
STRENGTH OF EBB

VELOCITY SCALE

5 0 5 10 15 20

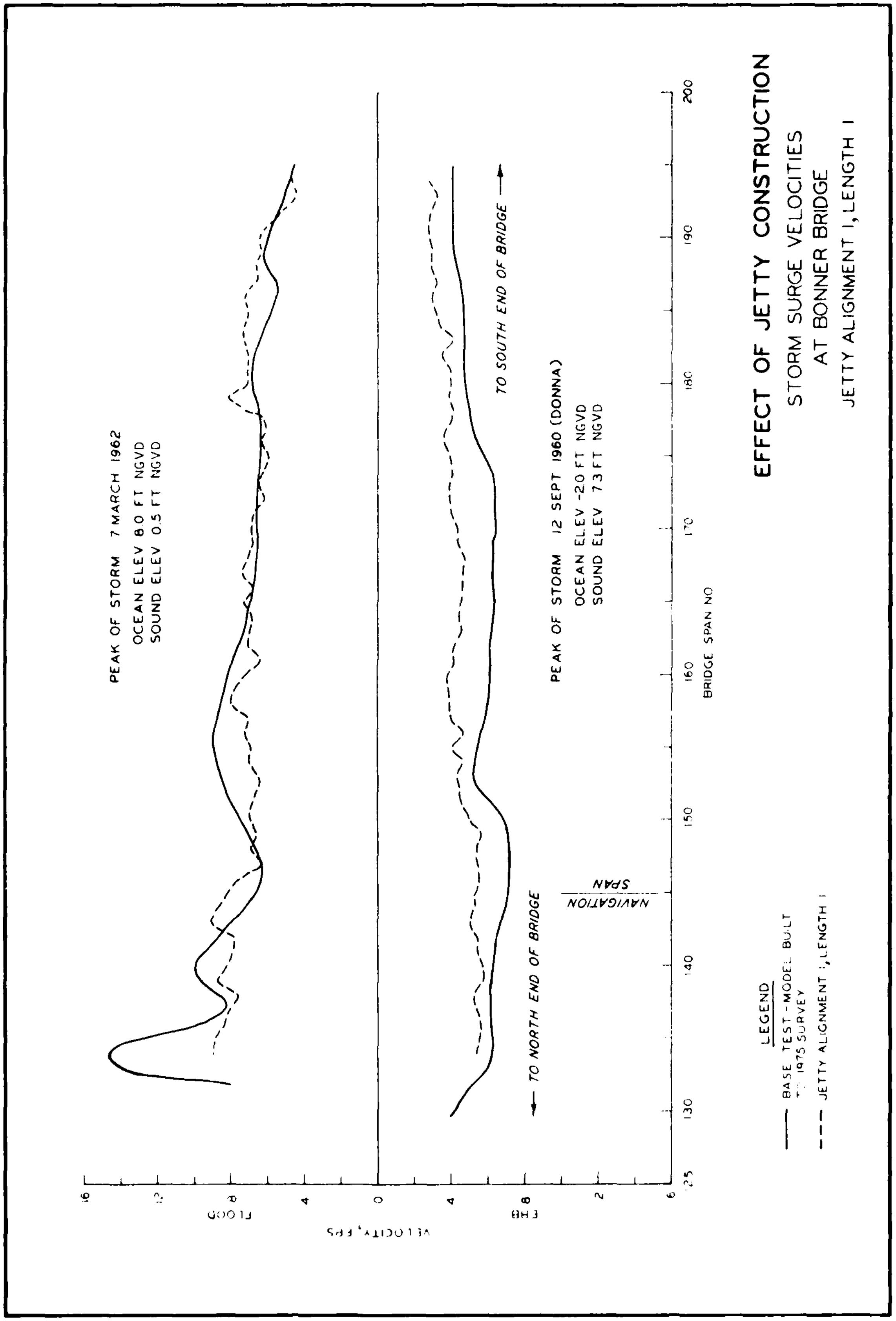
FT/SEC

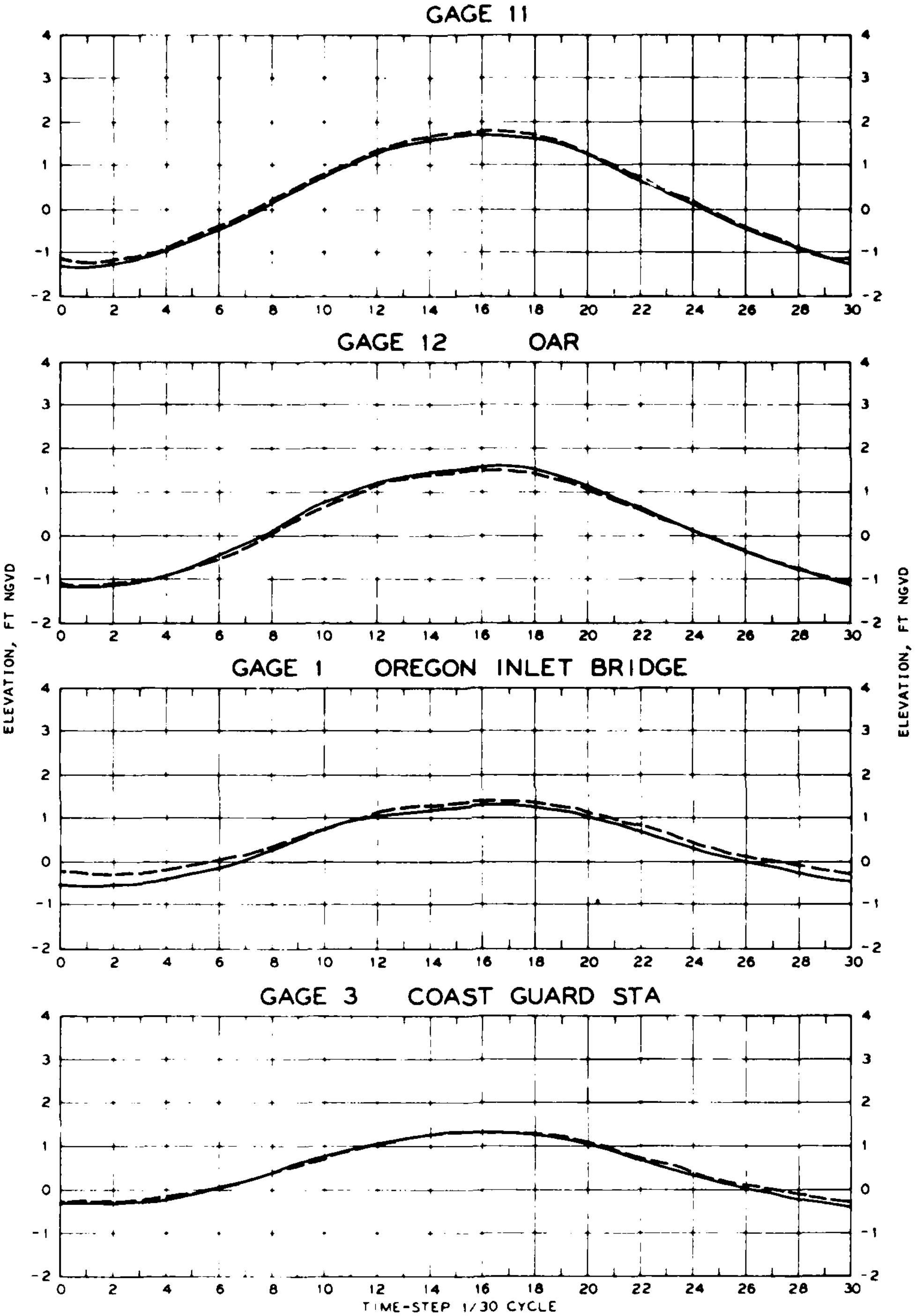
SURFACE CURRENT PHOTOGRAPHS

JETTY ALIGNMENT 1, LENGTH 1

TIME-STEP 16

STRENGTH OF FLOOD


EFFECT OF JETTY CONSTRUCTION
STORM SURGE VELOCITIES
AT BONNER BRIDGE
JETTY ALIGNMENT I, LENGTH I
PEAK OF STORM 7 MARCH 1962
OCEAN ELEV 8.0 FT NGVD
SOUND ELEV 0.5 FT NGVD
PEAK OF STORM 12 SEPT 1960 (DONNA)
OCEAN ELEV -2.0 FT NGVD
SOUND ELEV 7.3 FT NGVD
TO SOUTH END OF BRIDGE
TO NORTH END OF BRIDGE
NAVIGATION SPAN
BRIDGE SPAN NO
VELOCITY, FPS
FLOOD
EBB
LEGEND
BASE TEST - MODEL BUILT TO 1975 SURVEY
JETTY ALIGNMENT I, LENGTH I



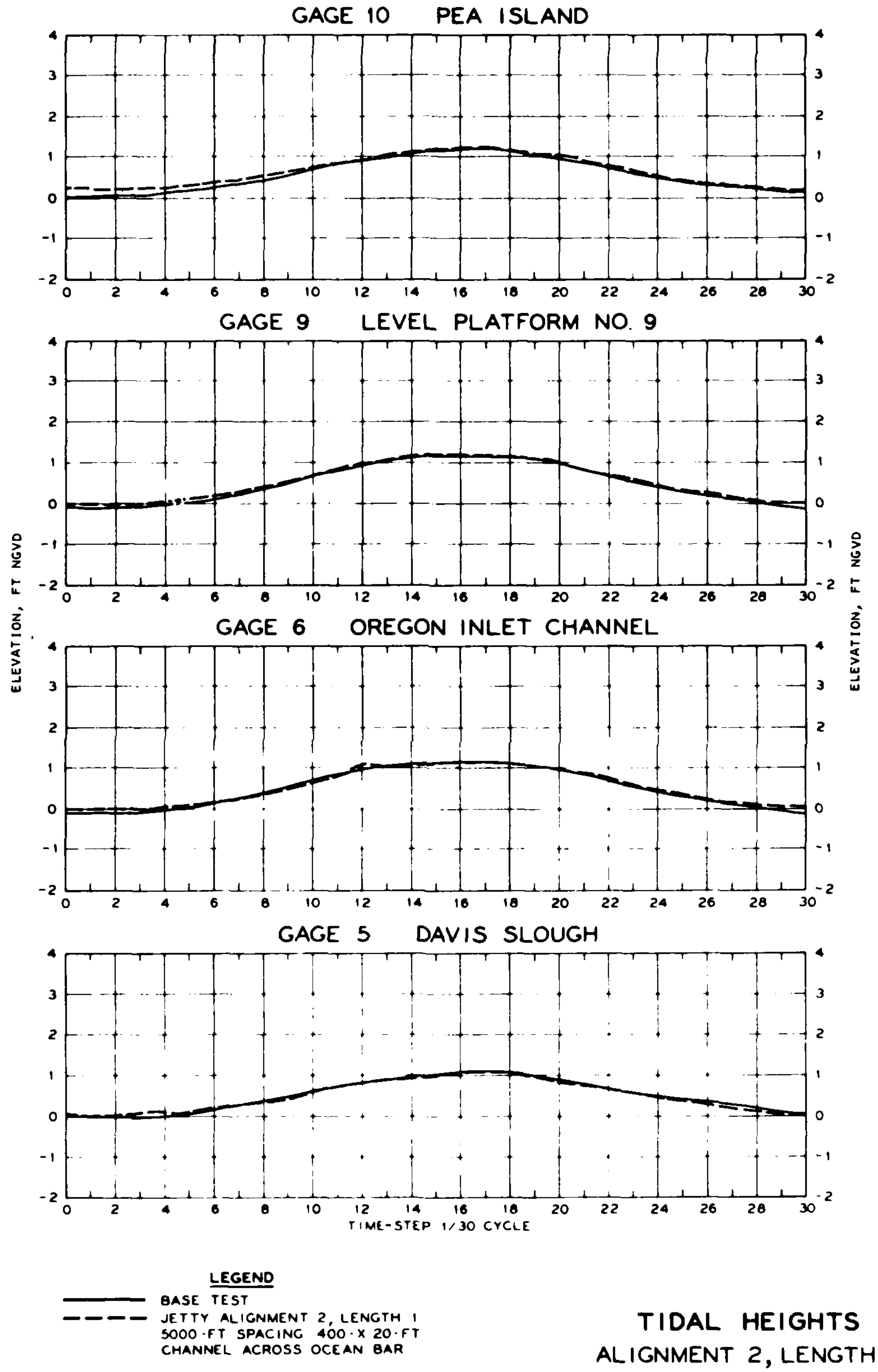
LEGEND

—— BASE TEST

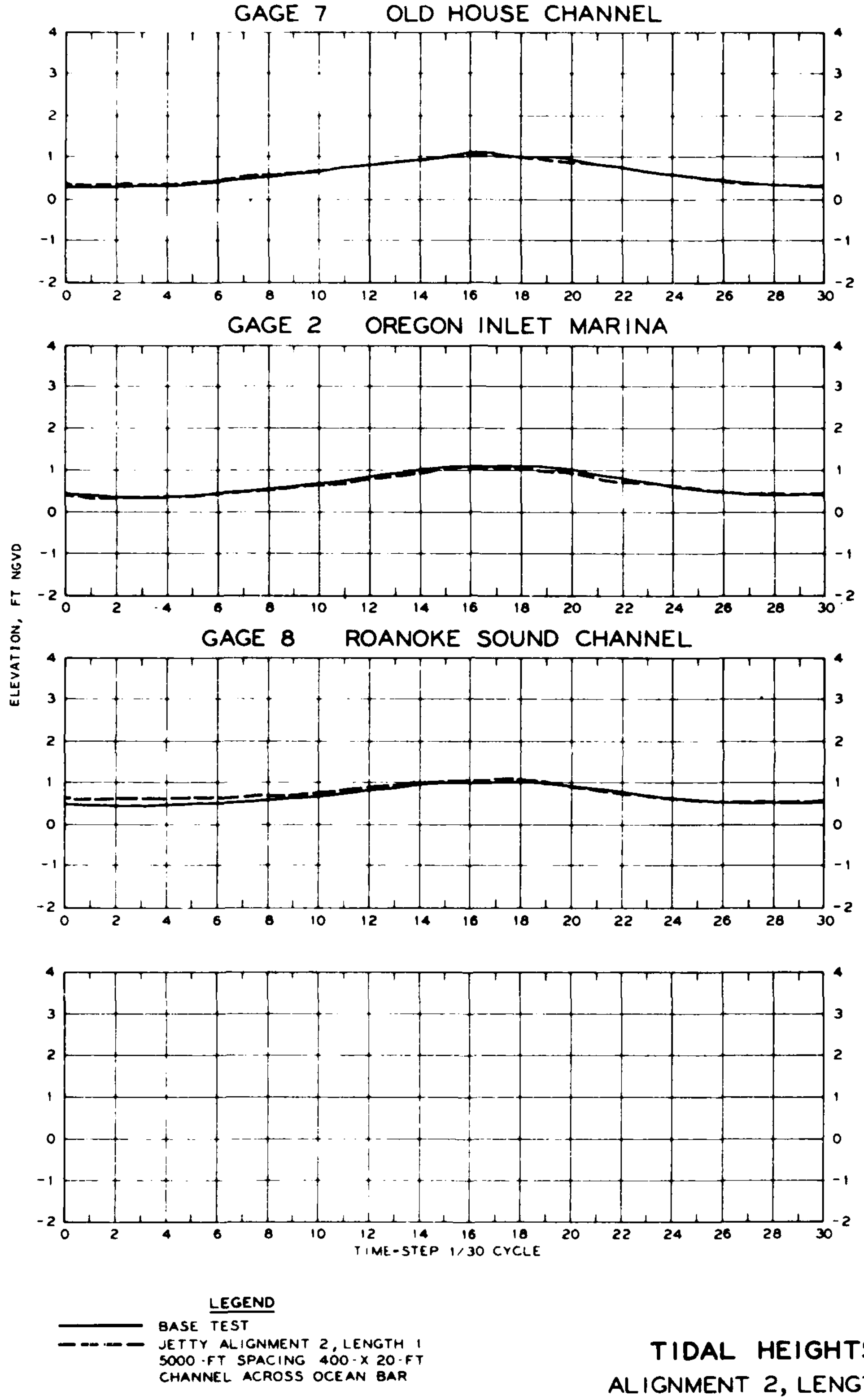
– – – JETTY ALIGNMENT 2, LENGTH 1 5000-FT SPACING 400-X 20-FT CHANNEL ACROSS OCEAN BAR

TIDAL HEIGHTS

ALIGNMENT 2, LENGTH 1
5000-FT SPACING
GAGES 11, 12, 1, AND 3

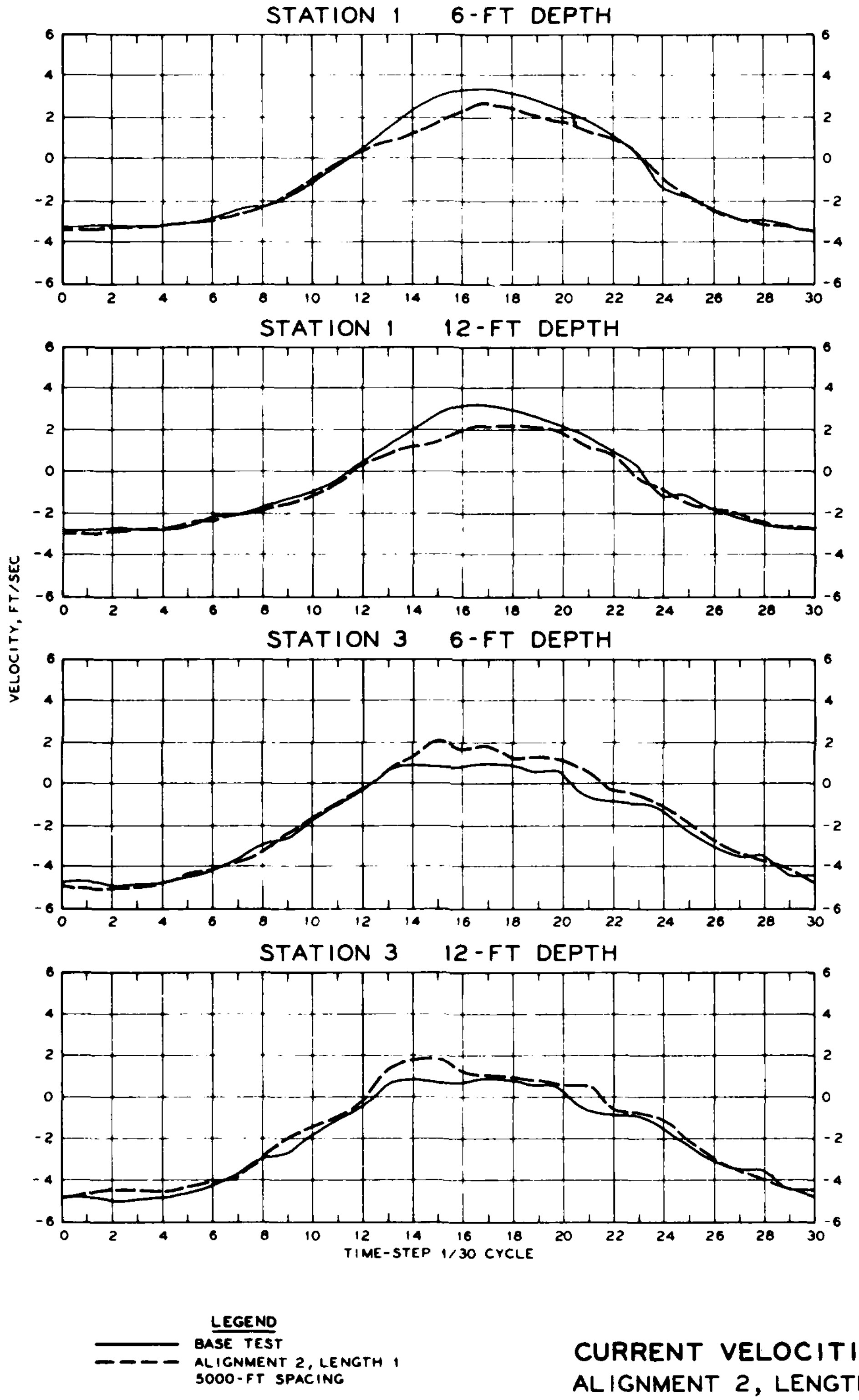


TIDAL HEIGHTS
ALIGNMENT 2, LENGTH 1
5000-FT SPACING
GAGES 10, 9, 6, AND 5

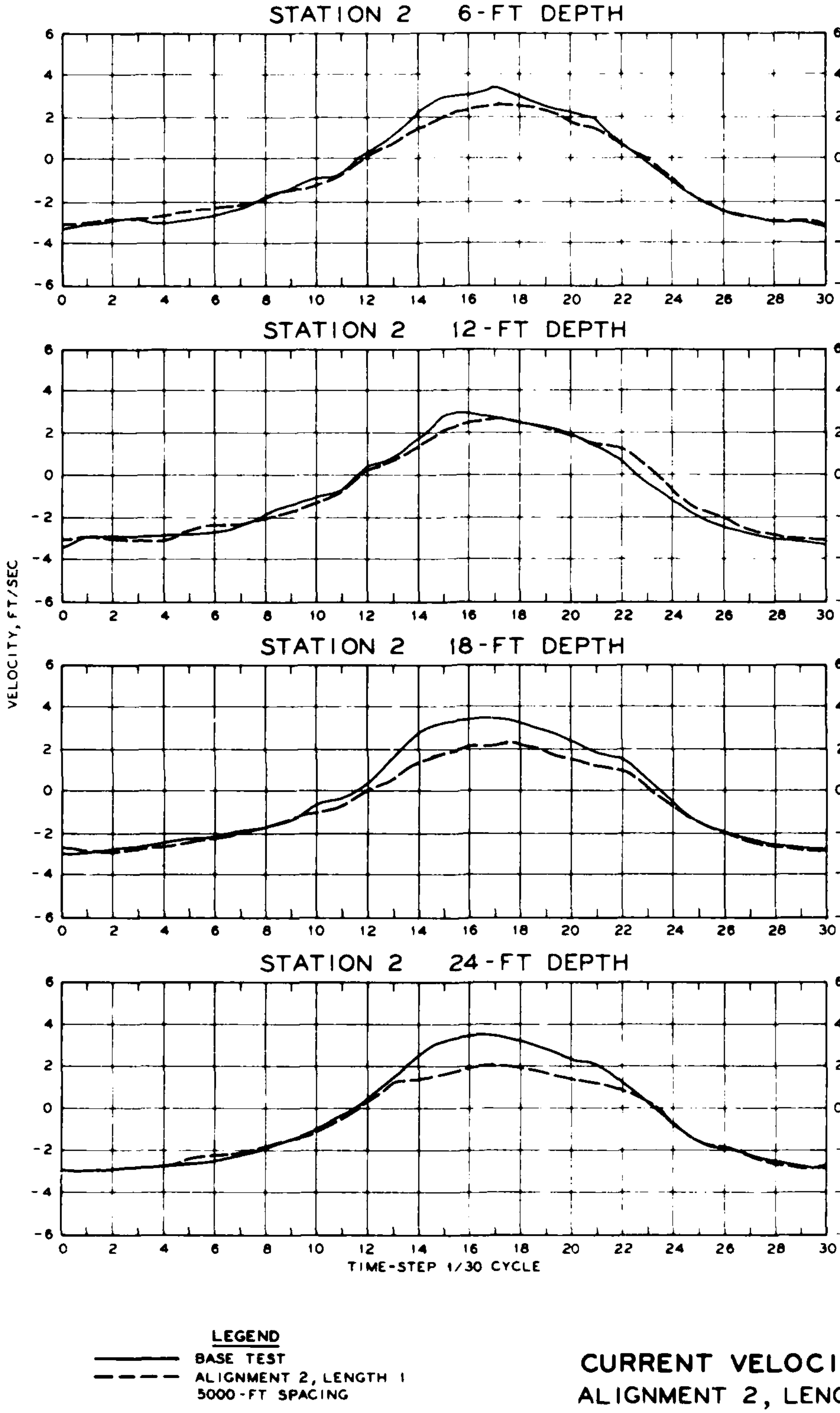


TIDAL HEIGHTS

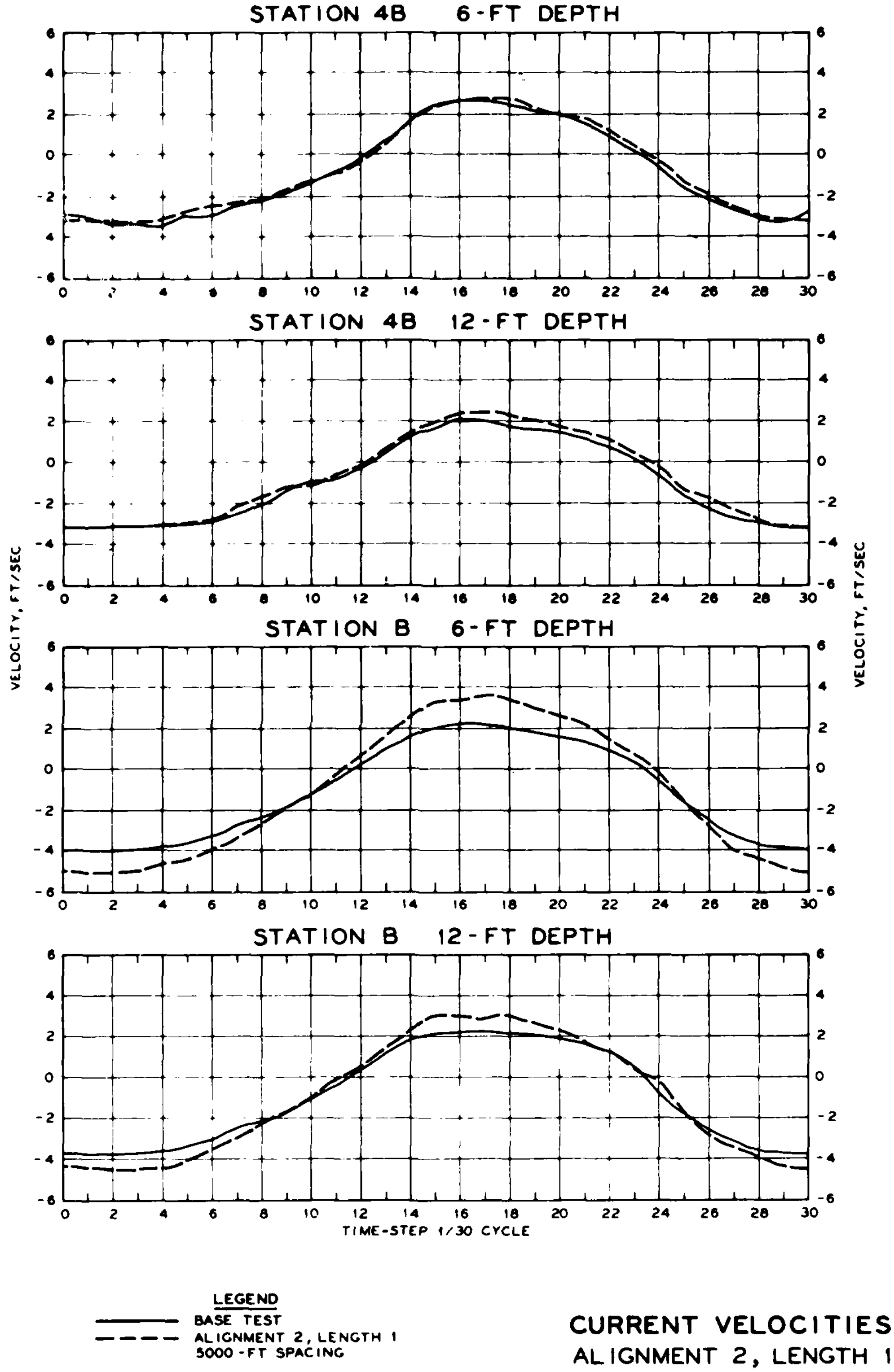
ALIGNMENT 2, LENGTH 1
5000-FT SPACING
GAGES 7, 2, AND 8



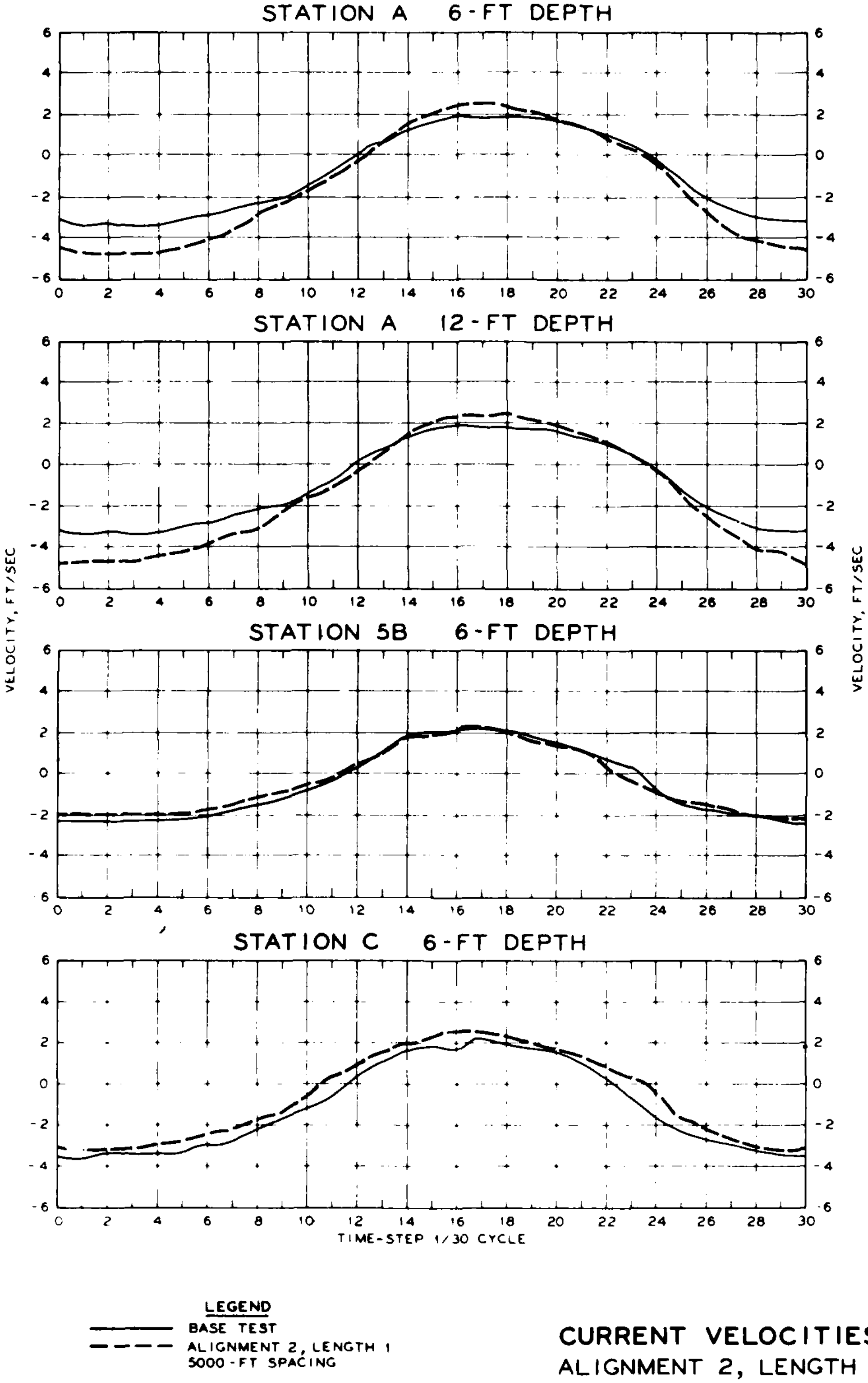
CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 1
5000-FT SPACING
STATIONS 1 AND 3



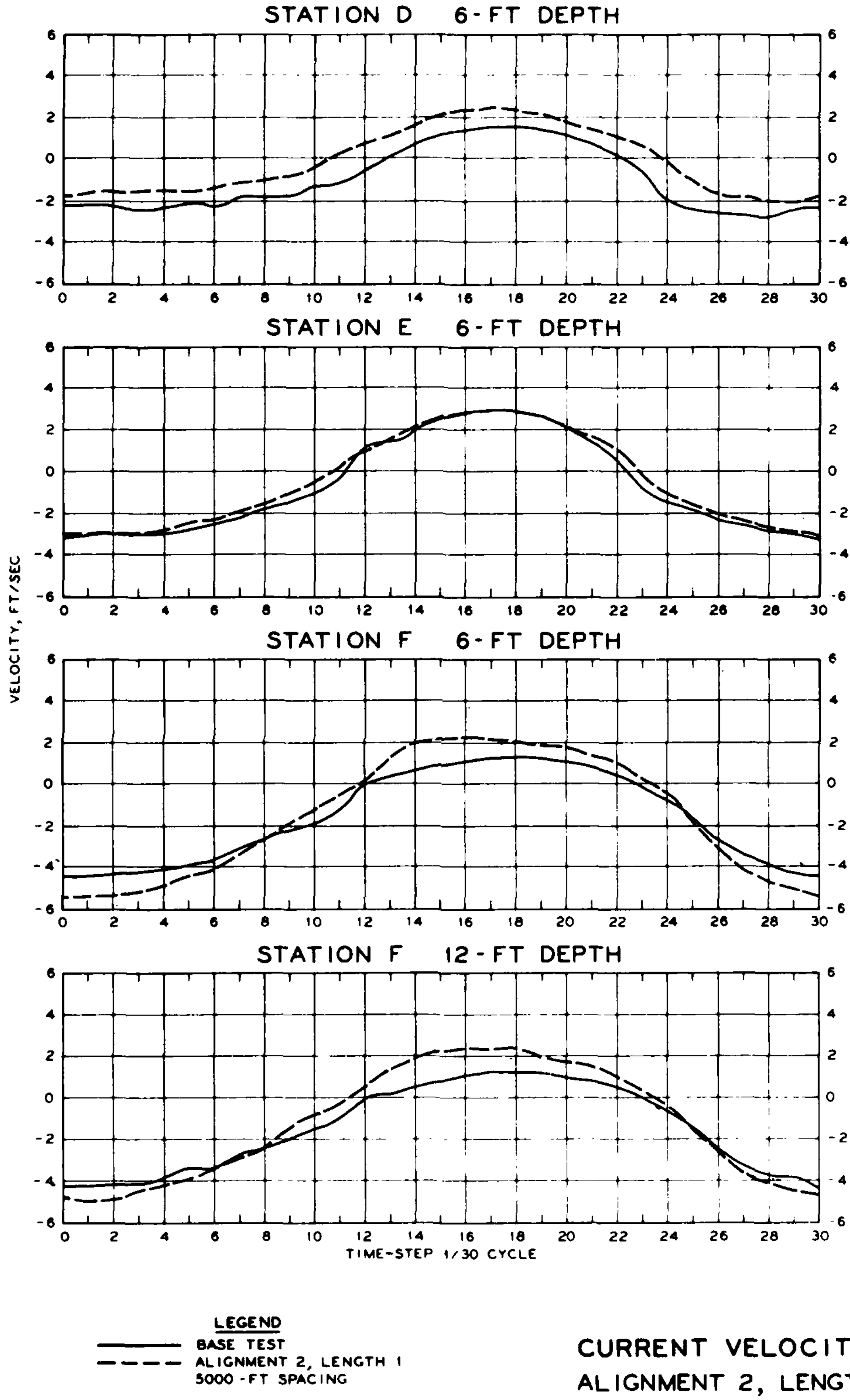
CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 1
5000-FT SPACING
STATION 2



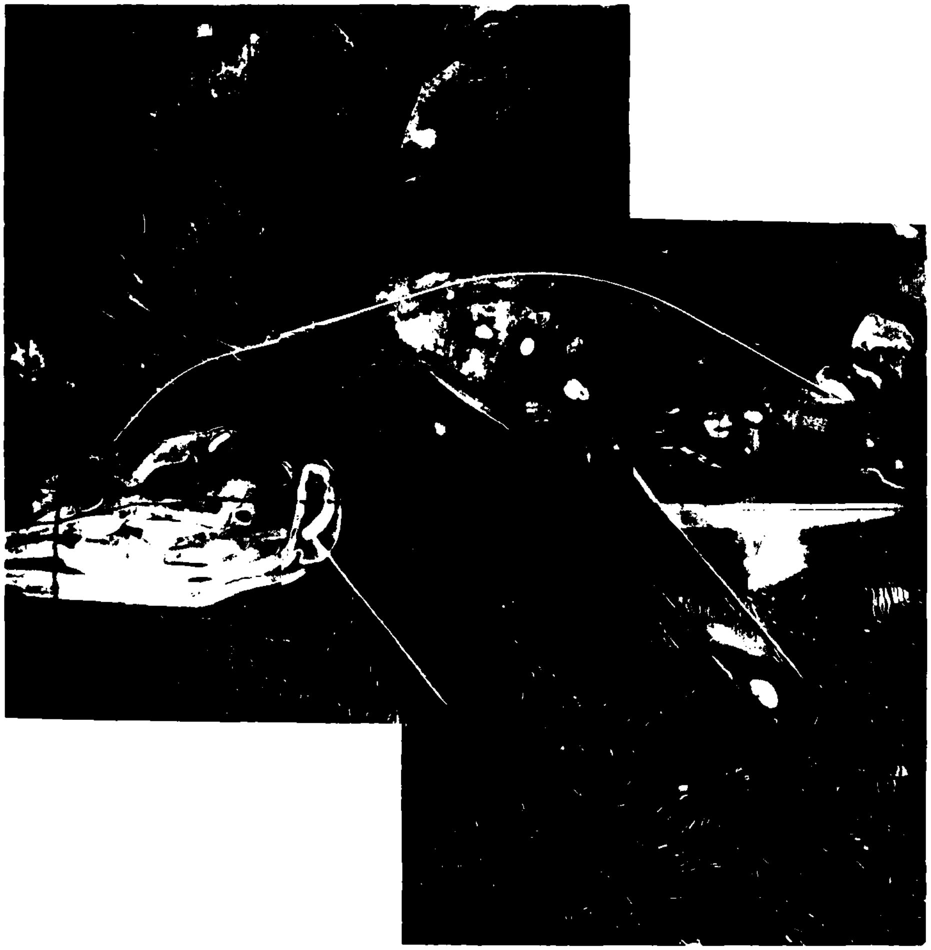
CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 1
5000-FT SPACING
STATIONS 4B, AND B



CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 1
5000-FT SPACING
STATIONS A, 5B, AND BRIDGE



CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 1
5000-FT SPACING
STATIONS D, E, AND F



VELOCITY SCALE

5 0 5 10 15 20

FT/SEC

SURFACE CURRENT
PHOTOGRAPHS

JETTY ALIGNMENT 2, LENGTH 1
5000-FT SPACING

TIME-STEP 0
STRENGTH OF EBB

VELOCITY SCALE

5 0 5 10 15 20

FT/SEC

SURFACE CURRENT
PHOTOGRAPHS

JETTY ALIGNMENT 2, LENGTH 1
5000-FT SPACING

TIME-STEP 15
STRENGTH OF FLOOD

VELOCITY SCALE
10 0 10 20 30 40
FT/SEC

SURFACE CURRENT PHOTOGRAPHS
SIMULATED STORM SURGE OF 12 SEPTEMBER 1960
JETTY ALIGNMENT 2, LENGTH 1
5000-FT SPACING
EBB

VELOCITY SCALE

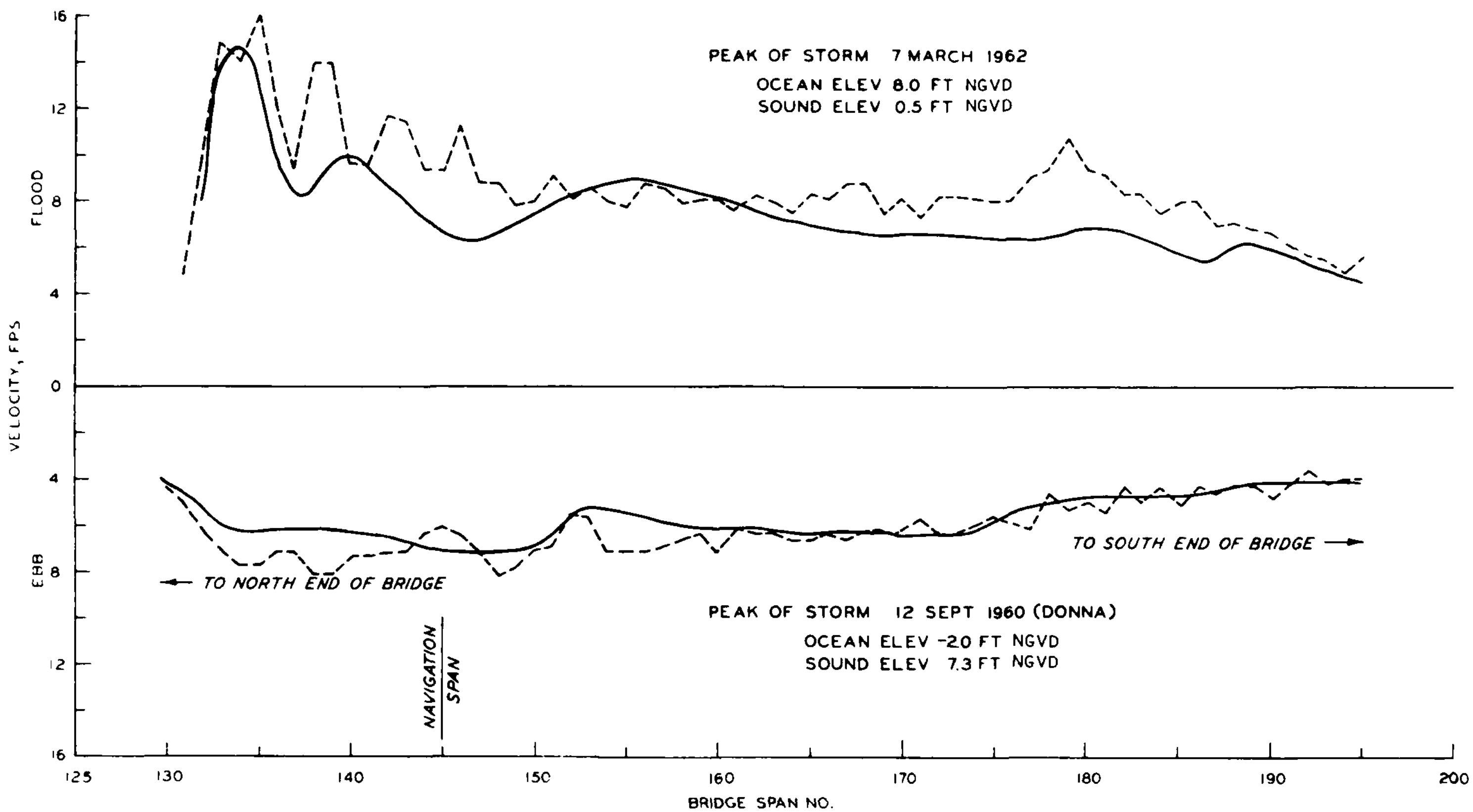
10 0 10 20 30 40

FT/SEC

SURFACE CURRENT
PHOTOGRAPHS

SIMULATED STORM SURGE OF
7 MARCH 1962

JETTY ALIGNMENT 2, LENGTH 1
5000-FT SPACING
FLOOD



LEGEND

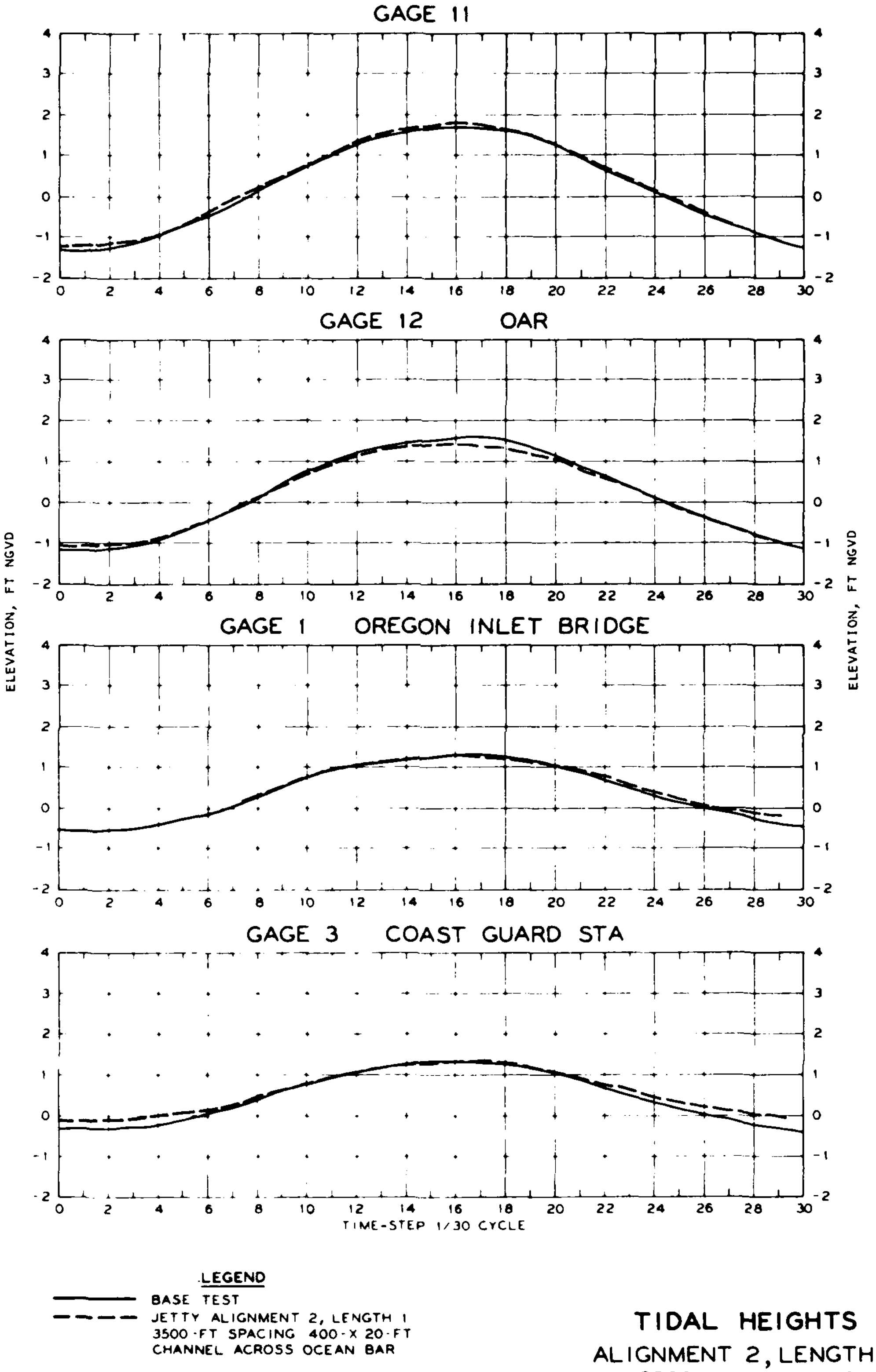
—— BASE TEST-MODEL BUILT TO 1975 SURVEY

– – – JETTY ALIGNMENT 2, LENGTH 1 5000 FT SPACING

EFFECT OF JETTY CONSTRUCTION

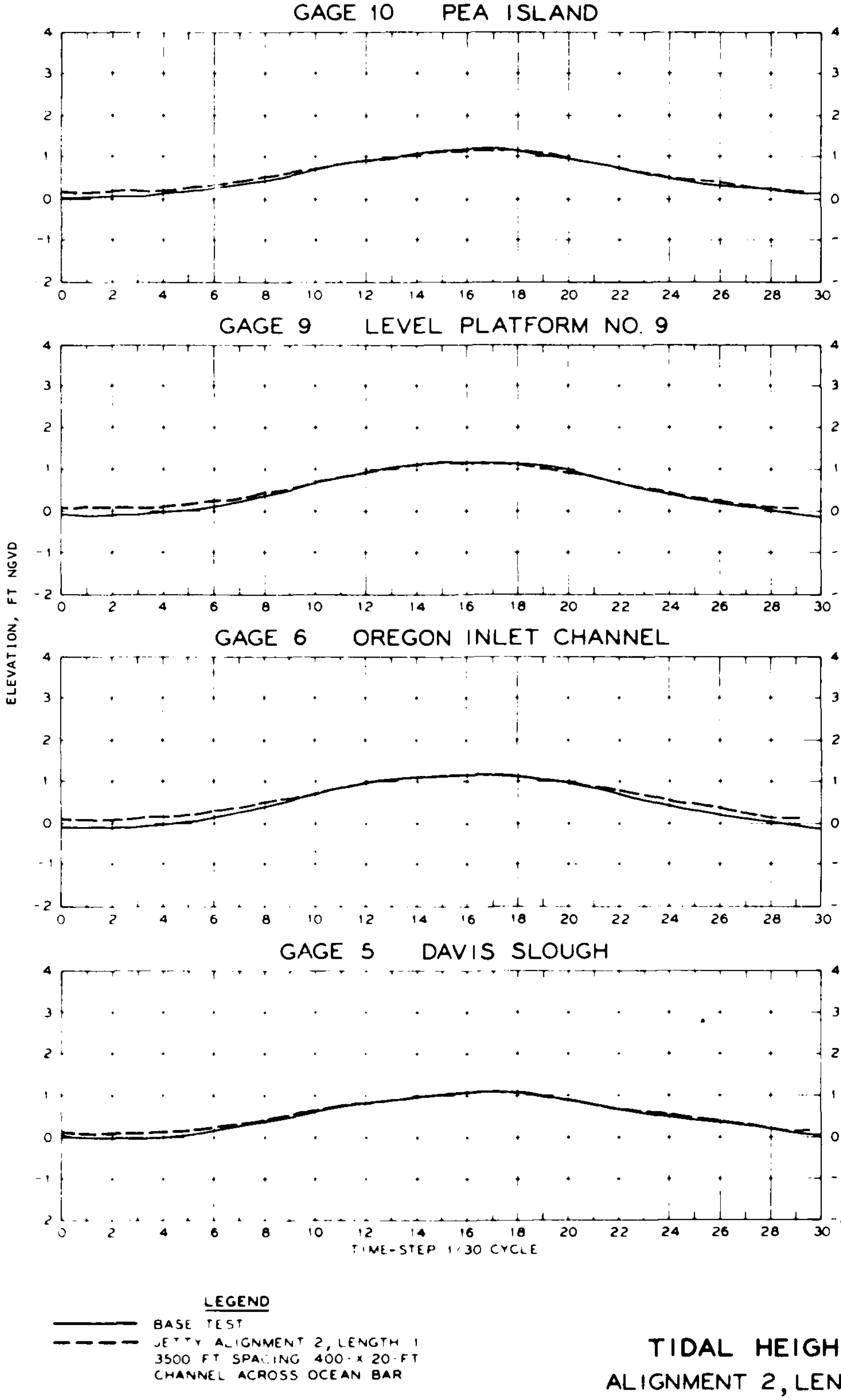
STORM SURGE VELOCITIES
AT BONNER BRIDGE

JETTY ALIGNMENT 2, LENGTH 1 5000-FT SPACING



TIDAL HEIGHTS

ALIGNMENT 2, LENGTH 1
3500-FT SPACING
GAGES 11, 12, 1, AND 3

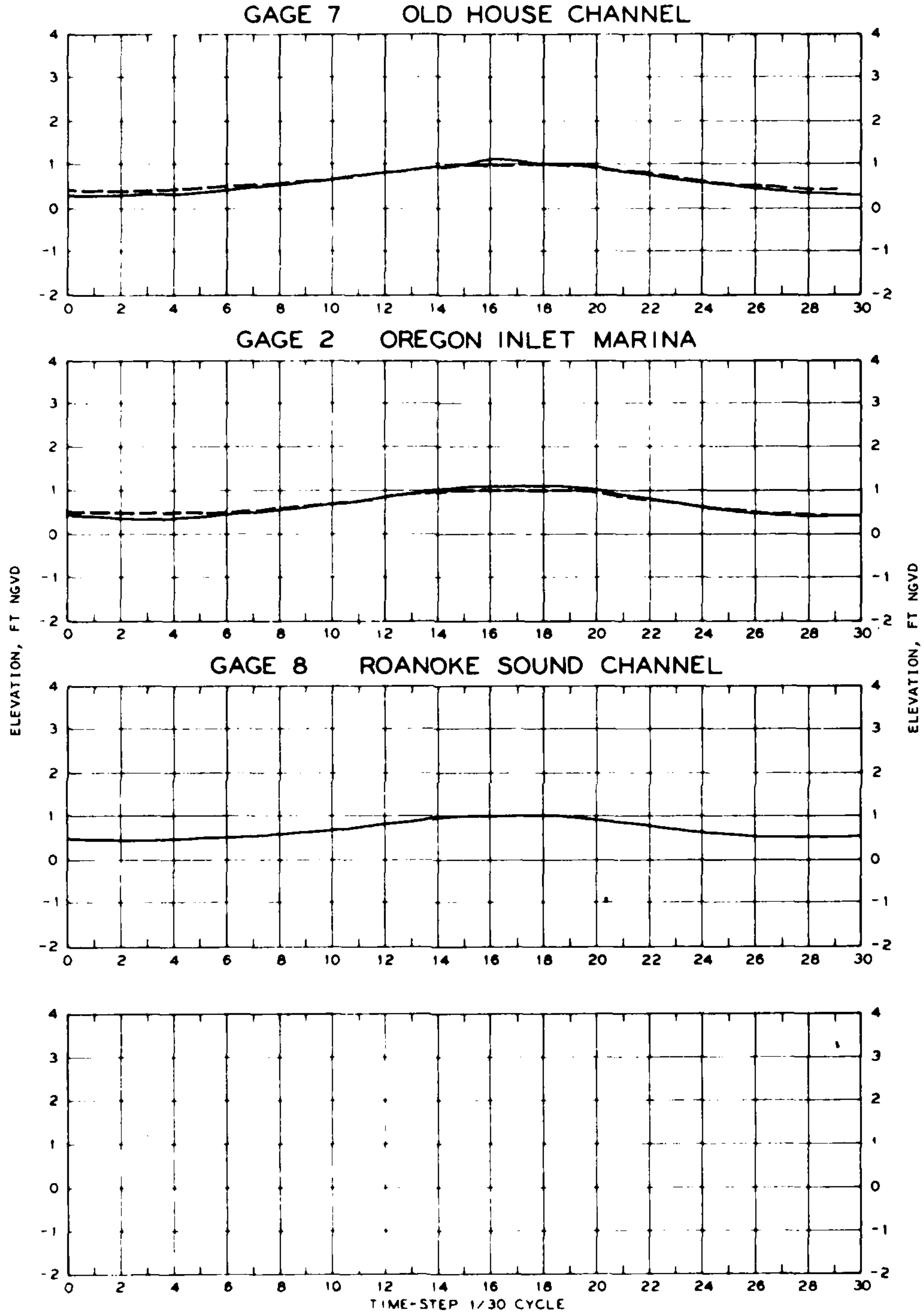


TIDAL HEIGHTS

ALIGNMENT 2, LENGTH 1

3500-FT SPACING

GAGES 10, 9, 6, AND 5



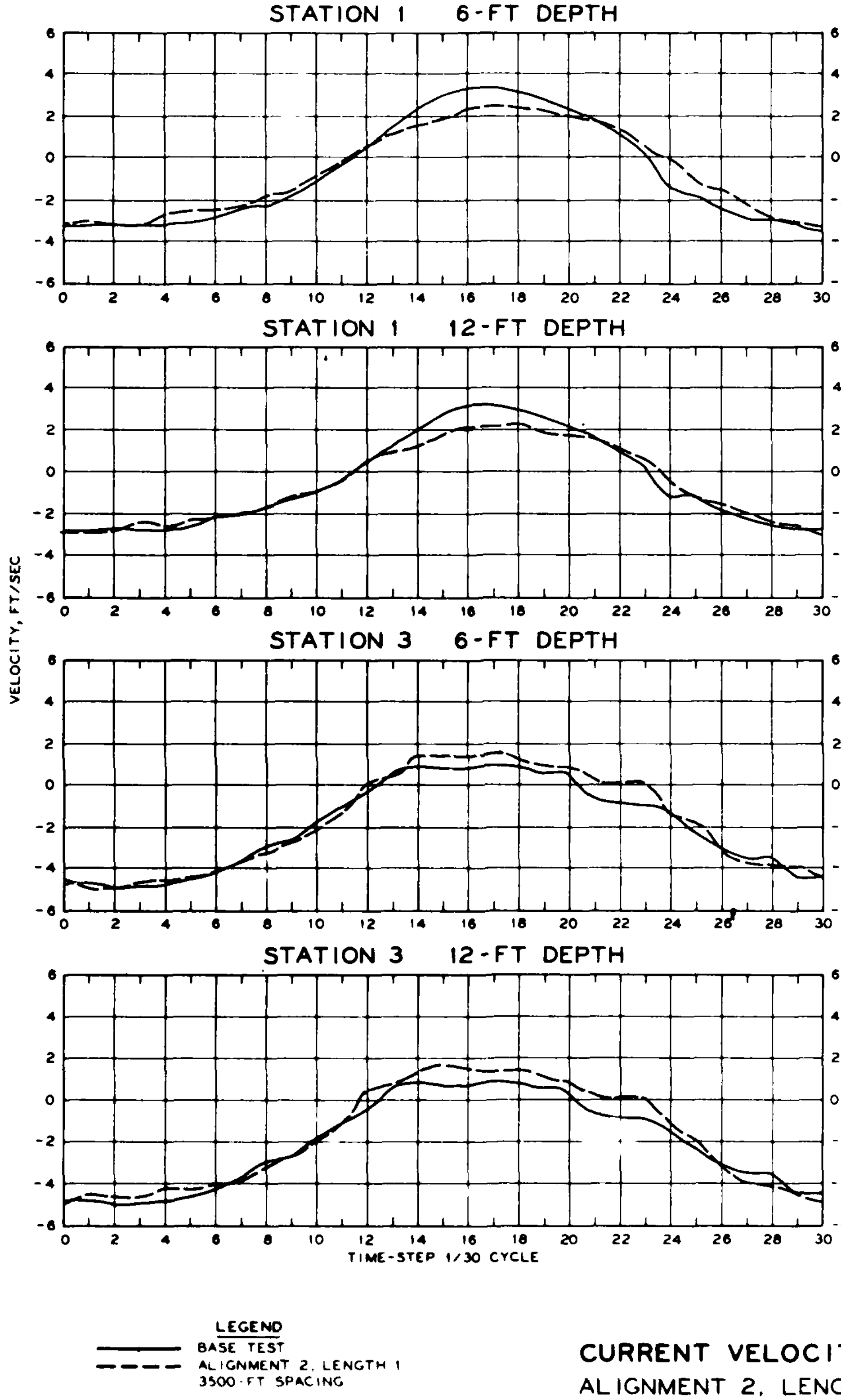
LEGEND

BASE TEST

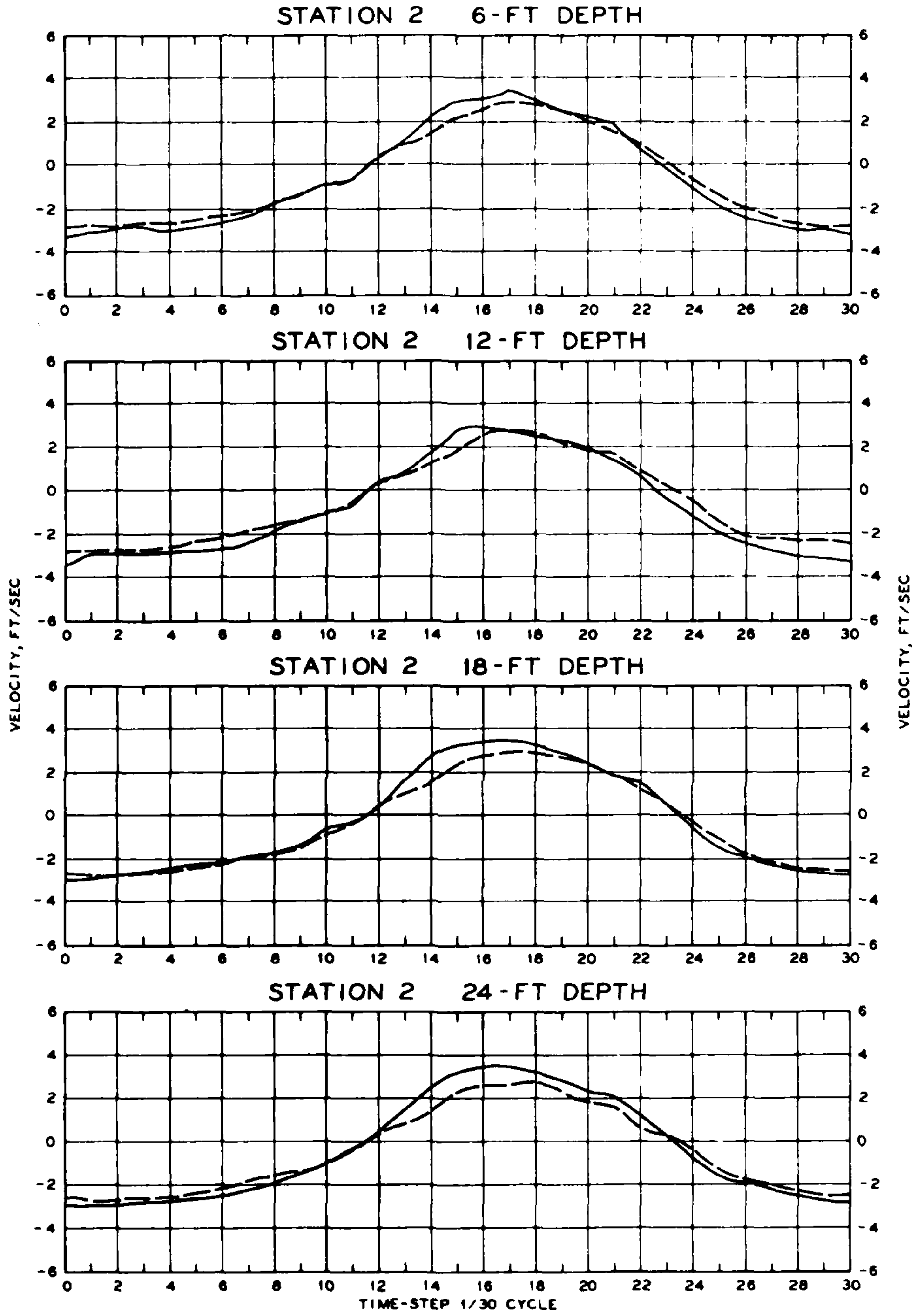
JETTY ALIGNMENT 2, LENGTH 1 3500-FT SPACING 400-X 20-FT CHANNEL ACROSS OCEAN BAR

TIDAL HEIGHTS

ALIGNMENT 2, LENGTH 1
3500-FT SPACING
GAGES 7, 2, AND 8



CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 1
3500-FT SPACING
STATIONS 1 AND 3



LEGEND

——— BASE TEST

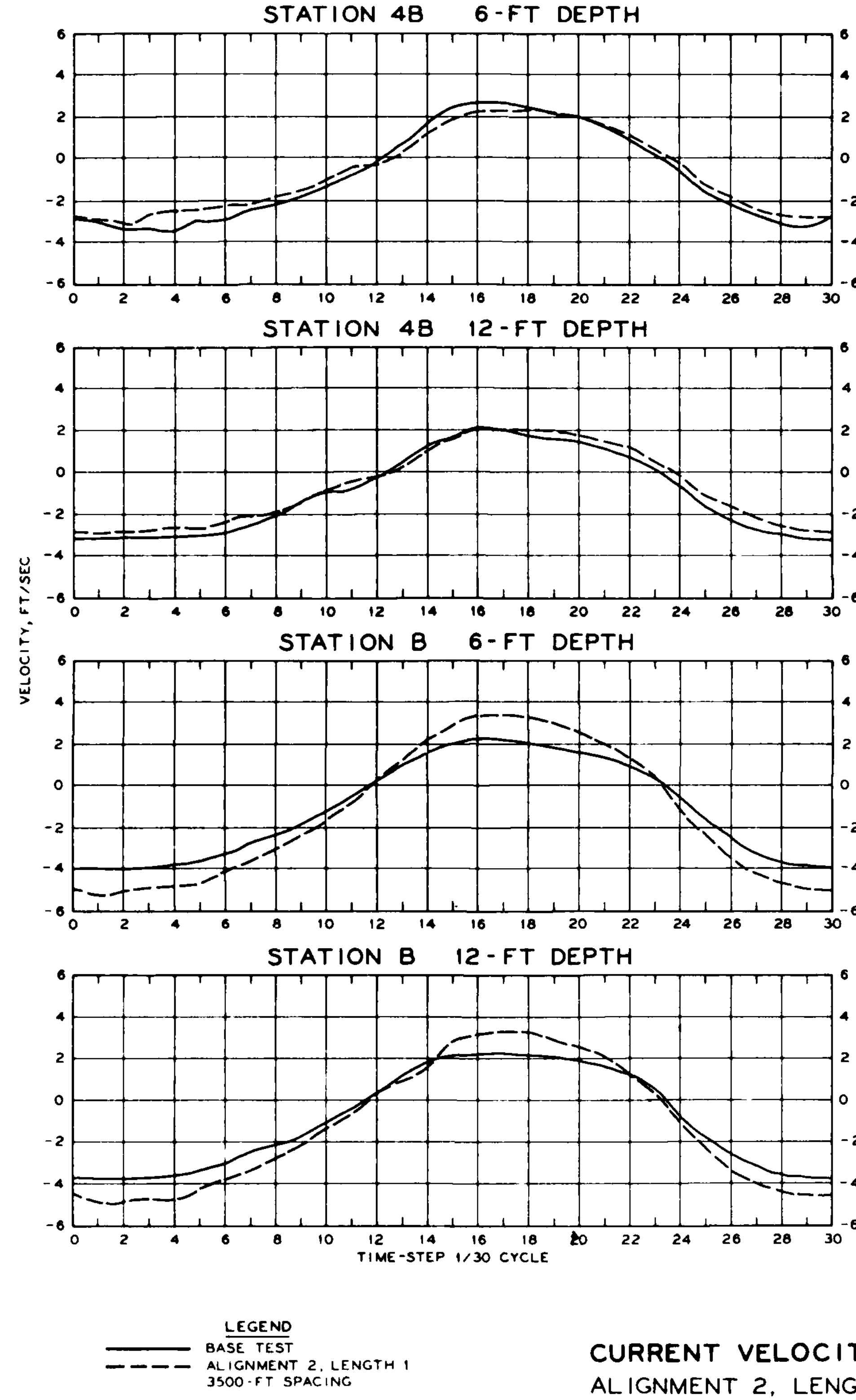
– – – – ALIGNMENT 2, LENGTH 1 3500-FT SPACING

CURRENT VELOCITIES

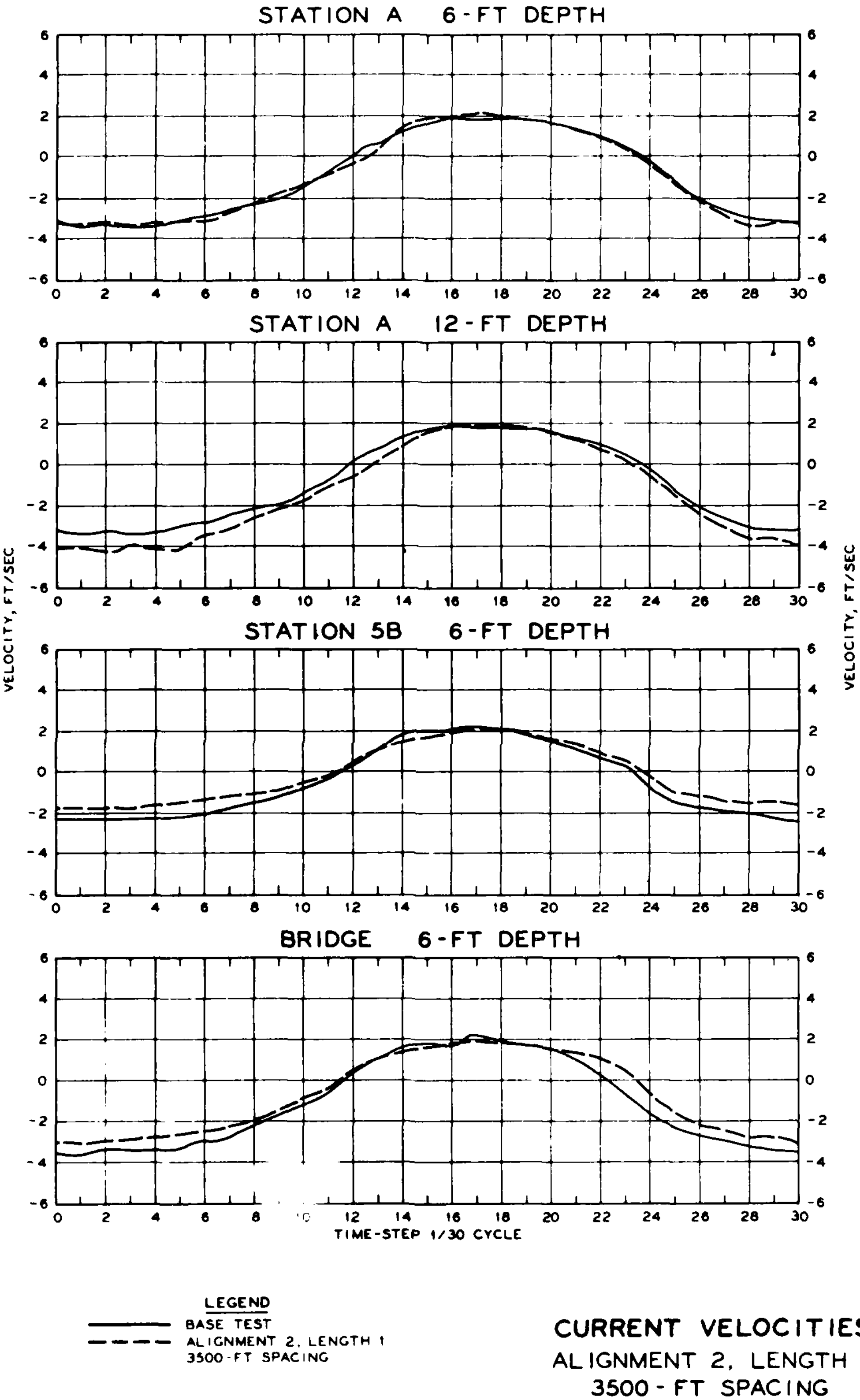
ALIGNMENT 2, LENGTH 1

3500-FT SPACING

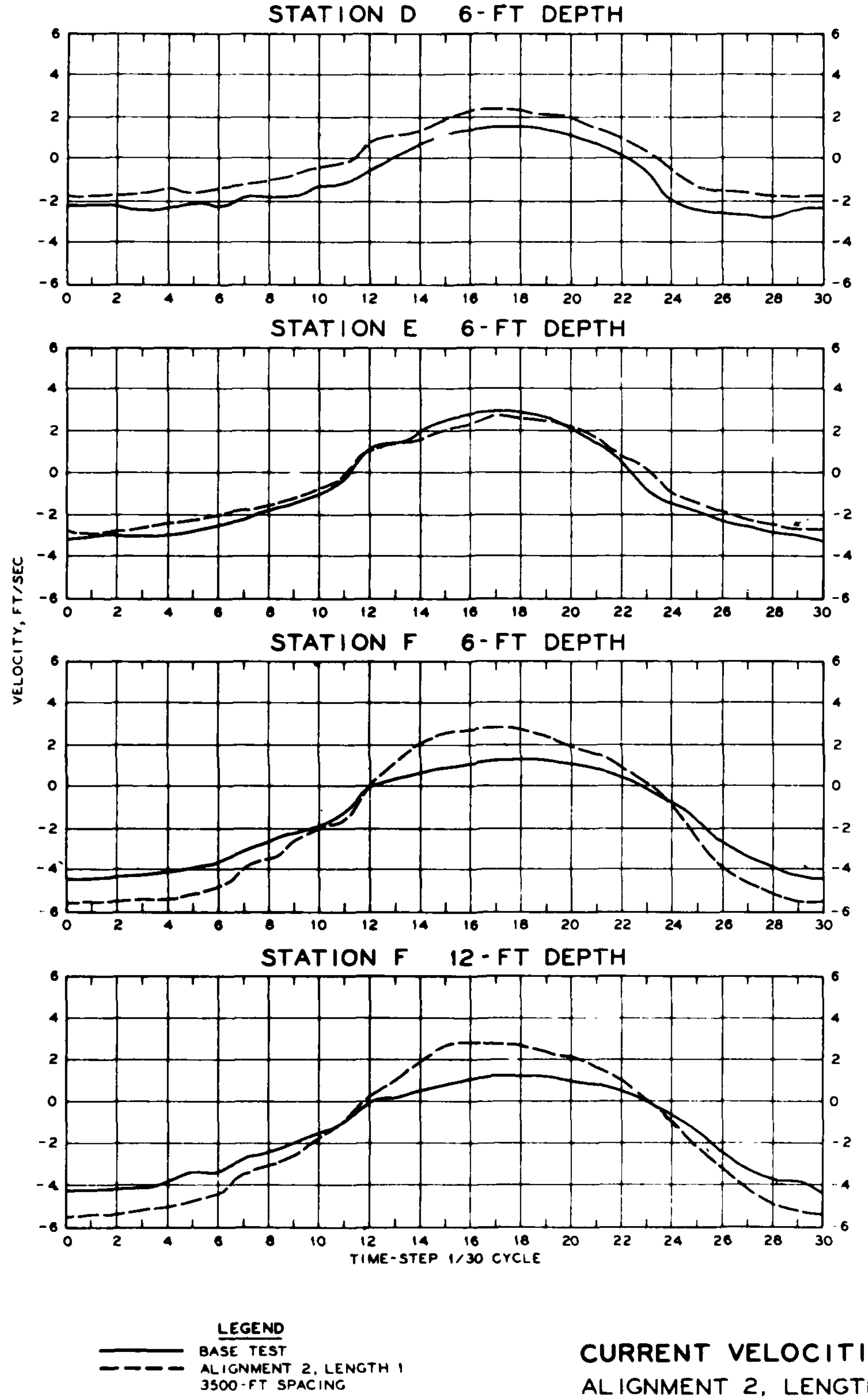
STATION 2



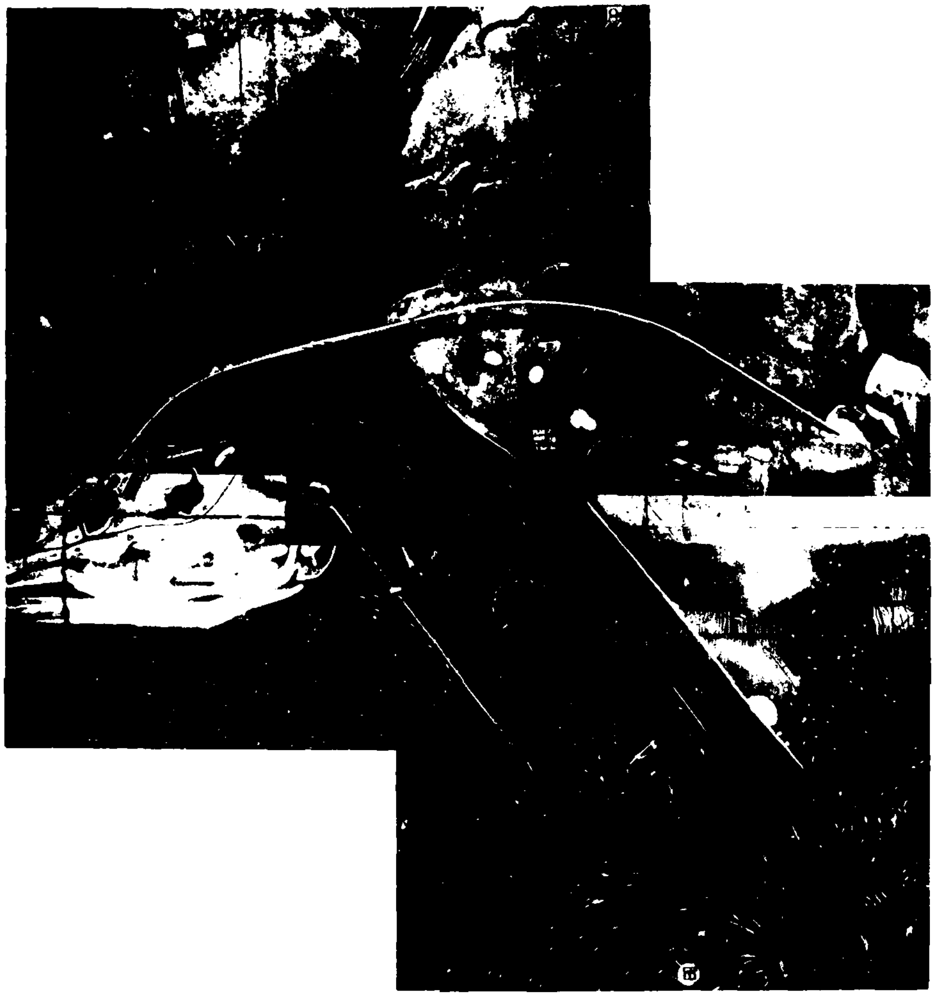
CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 1
3500 - FT SPACING
STATIONS 4B, AND B



CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 1
3500-FT SPACING
STATIONS A, 5B, AND BRIDGE



CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 1
3500-FT SPACING
STATIONS D, E, AND F

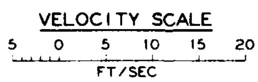


VELOCITY SCALE
5 0 5 10 15 20
FT/SEC

SURFACE CURRENT PHOTOGRAPHS

JETTY ALIGNMENT 2, LENGTH 1
3500-FT SPACING

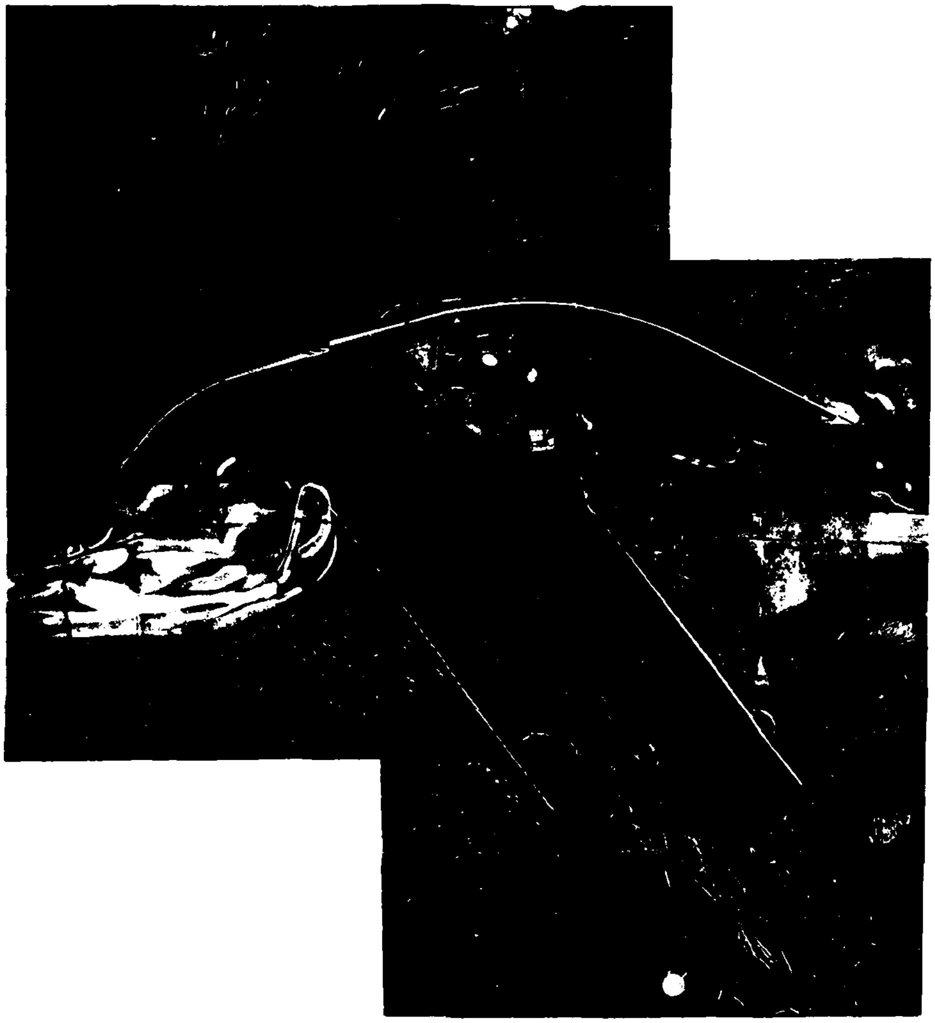
TIME-STEP 0
STRENGTH OF EBB



SURFACE CURRENT PHOTOGRAPHS

JETTY ALIGNMENT 2, LENGTH 1
3500-FT SPACING

TIME-STEP 15
STRENGTH OF FLOOD



VELOCITY SCALE

10 0 10 20 30 40

FT/SEC

SURFACE CURRENT
PHOTOGRAPHS

SIMULATED STORM SURGE OF
12 SEPTEMBER 1960

JETTY ALIGNMENT 2, LENGTH 1
3500-FT SPACING

VELOCITY SCALE

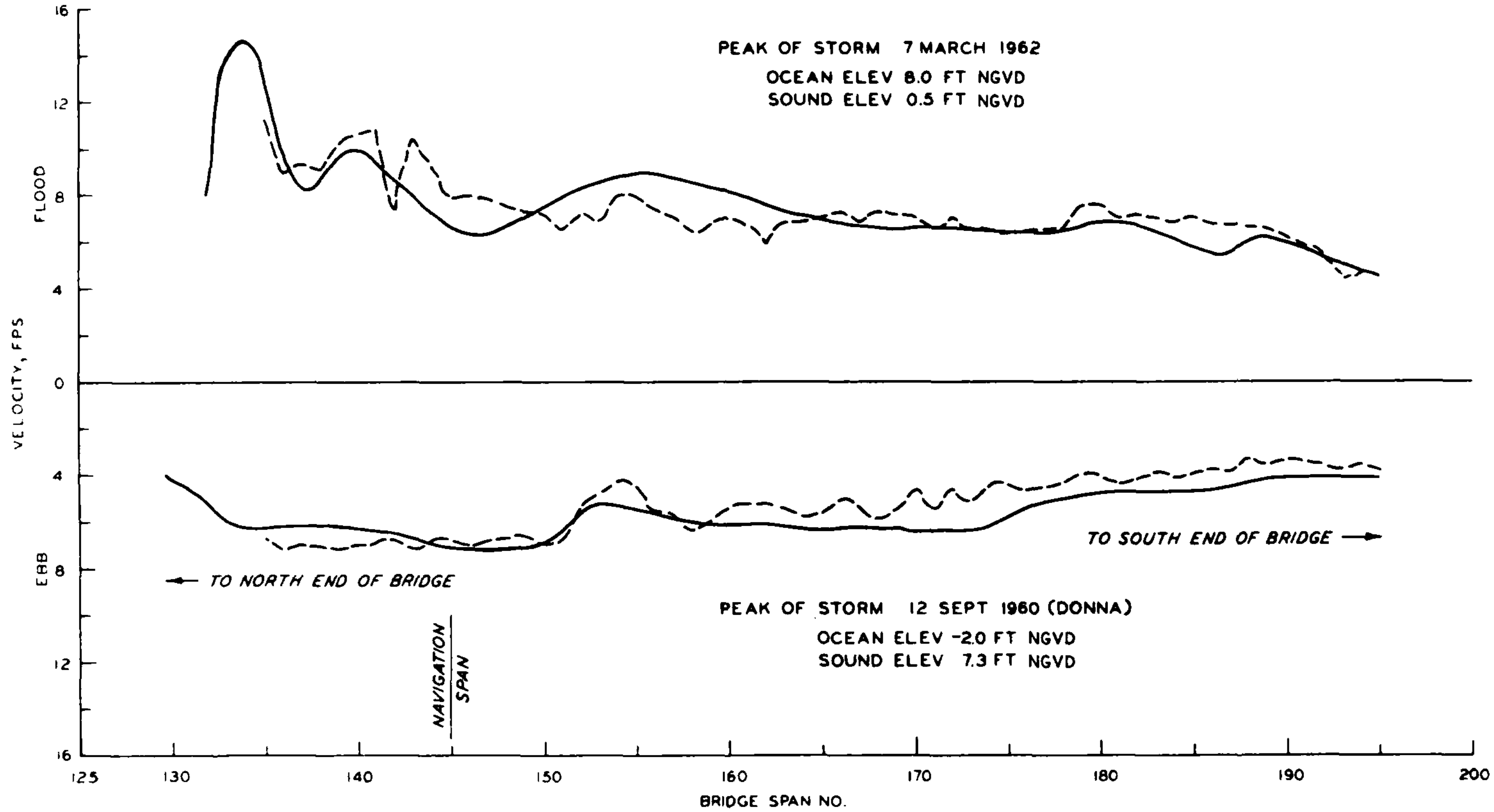
10 0 10 20 30 40

FT/SEC

SURFACE CURRENT
PHOTOGRAPHS

SIMULATED STORM SURGE OF
7 MARCH 1962

JETTY ALIGNMENT 2, LENGTH 1
3500-FT SPACING



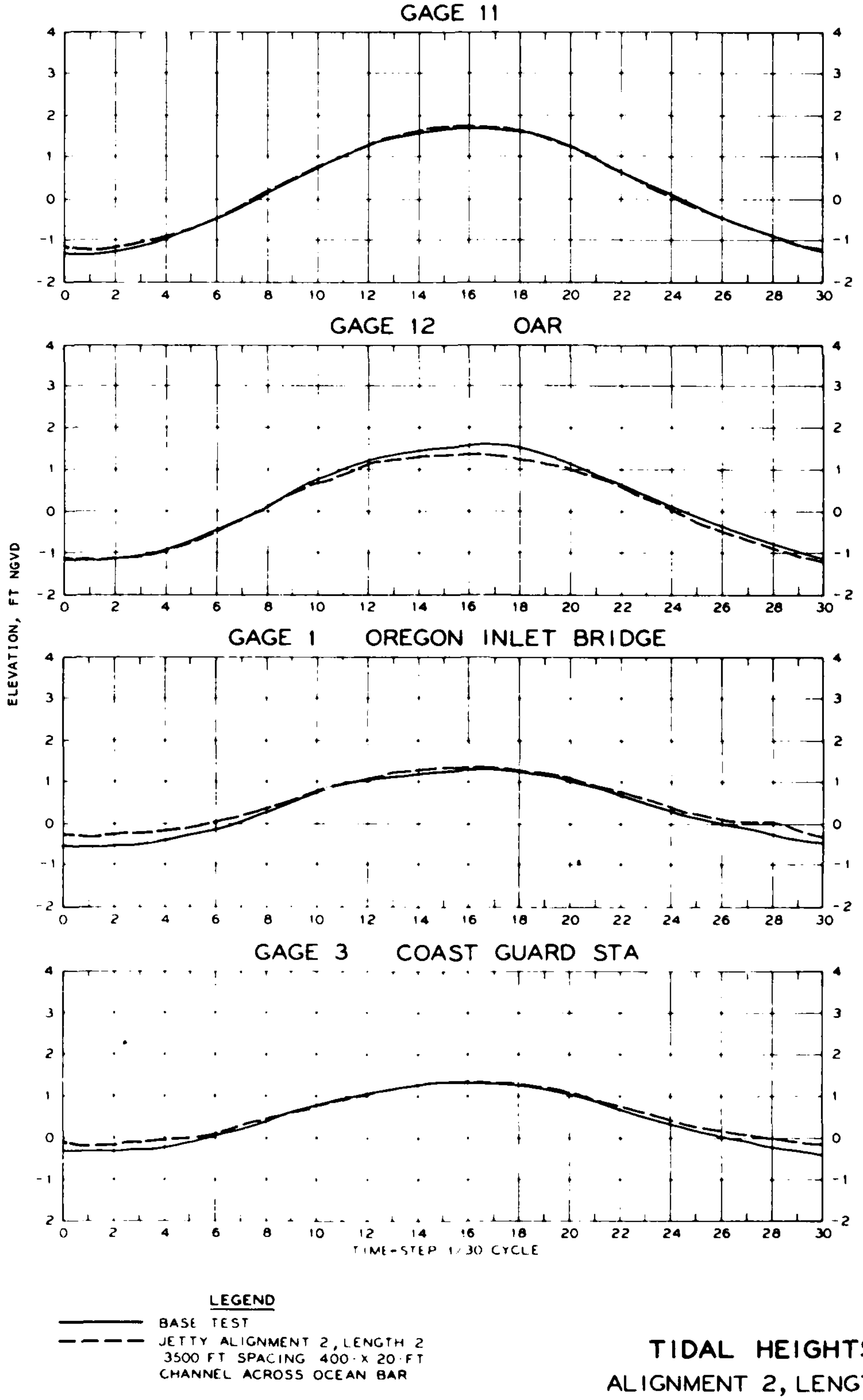
LEGEND

—— BASE TEST-MODEL BUILT TO 1975 SURVEY

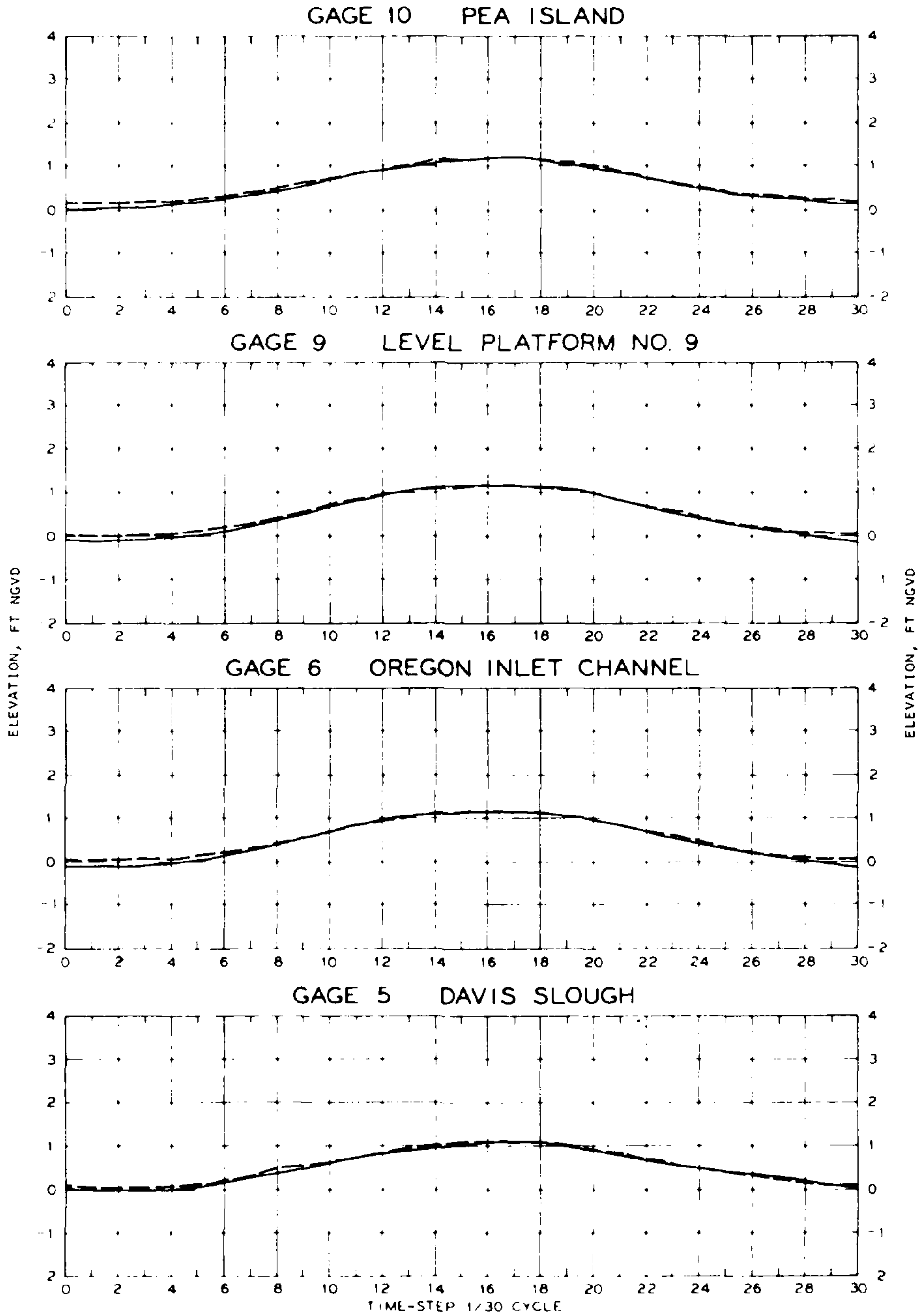
– – – JETTY ALIGNMENT 2, LENGTH 1 3500-FT SPACING

EFFECT OF JETTY CONSTRUCTION

STORM SURGE VELOCITIES
AT BONNER BRIDGE
JETTY ALIGNMENT 2, LENGTH 1 3500-FT SPACING



TIDAL HEIGHTS
ALIGNMENT 2, LENGTH 2
3500-FT SPACING
GAGES 11, 12, 1, AND 3



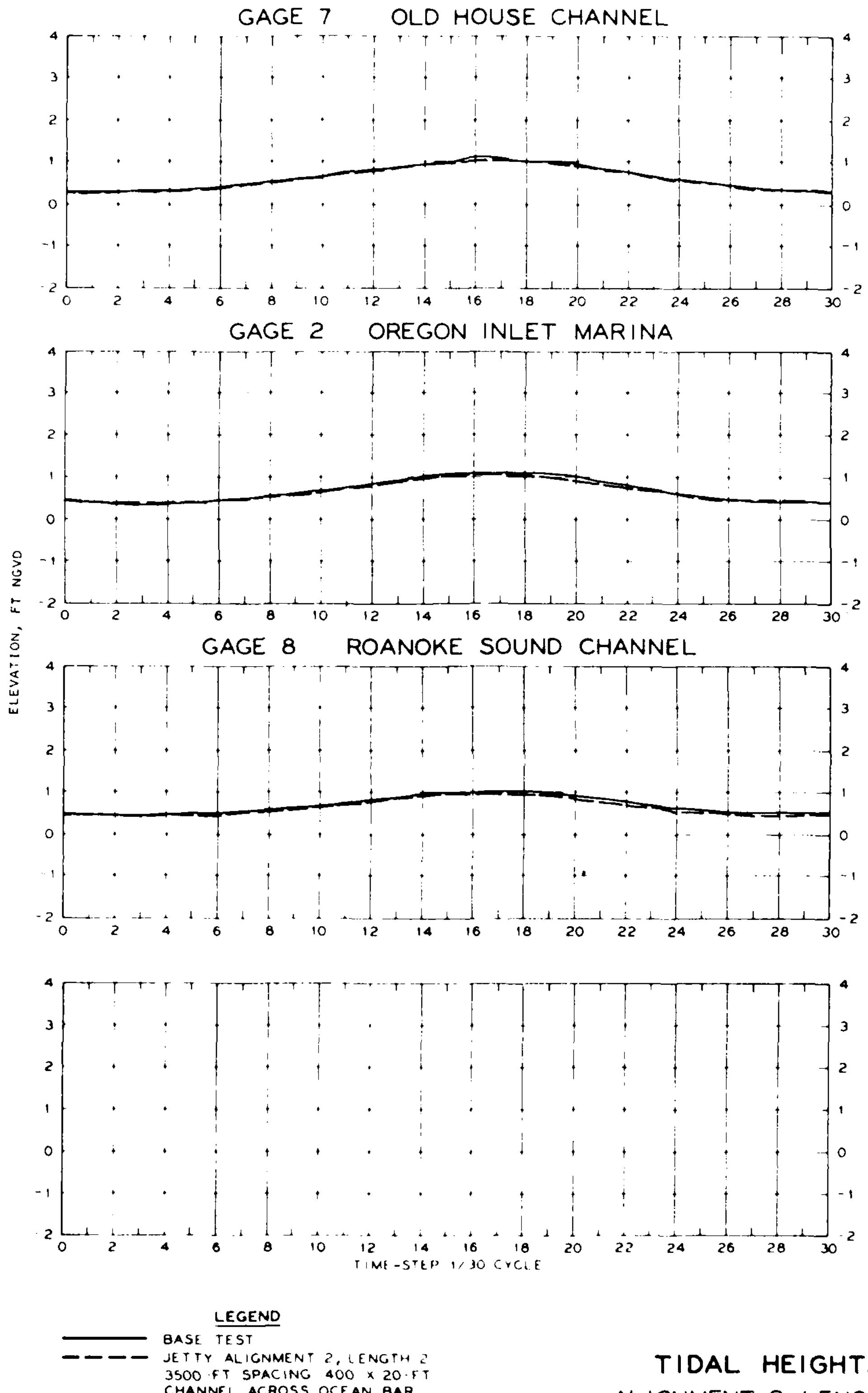
LEGEND

BASE TEST

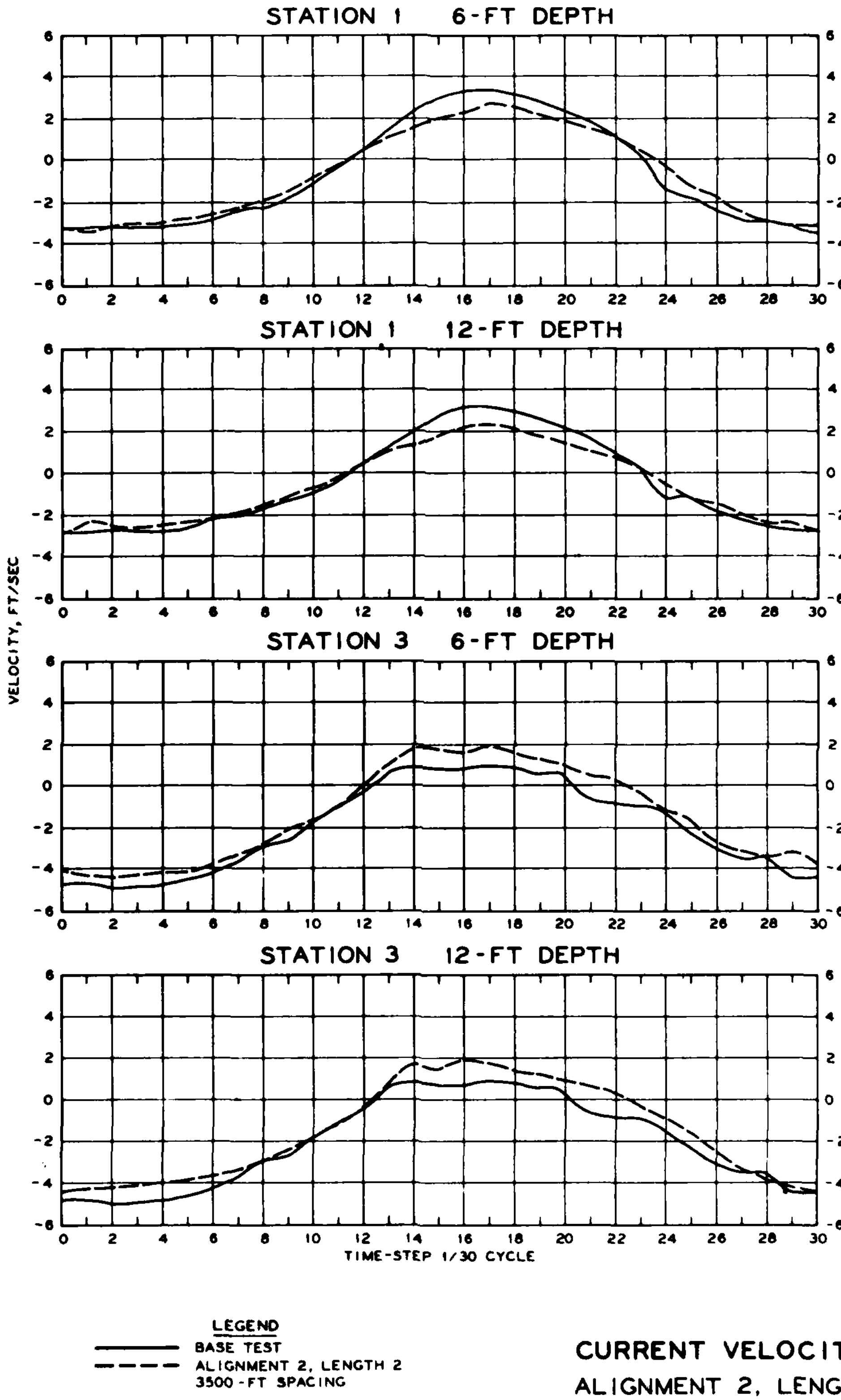
JETTY ALIGNMENT 2, LENGTH 2 3500-FT SPACING 400-X 20-FT CHANNEL ACROSS OCEAN BAR

TIDAL HEIGHTS

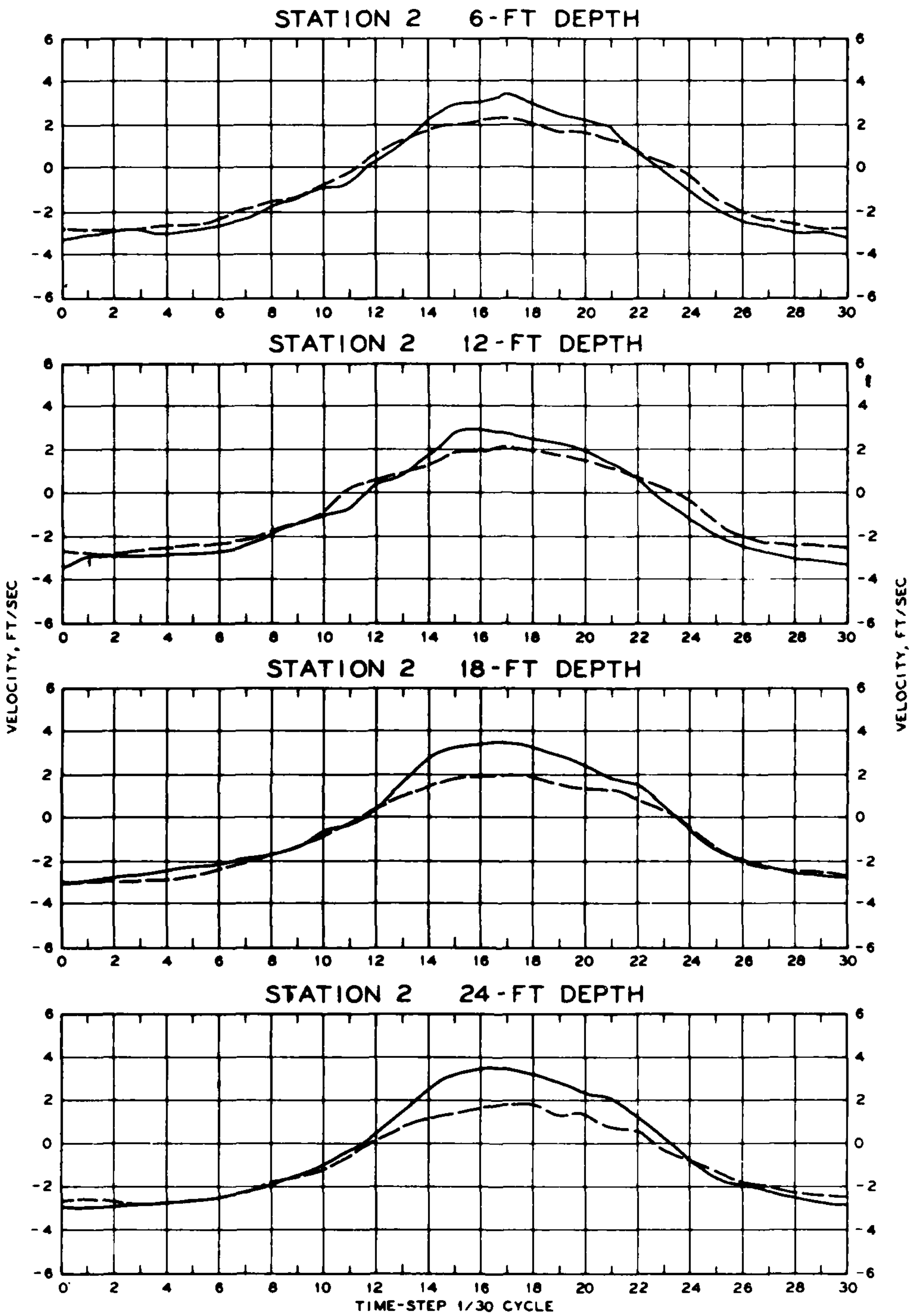
ALIGNMENT 2, LENGTH 2
3500-FT SPACING
GAGES 10, 9, 6, AND 5



TIDAL HEIGHTS
ALIGNMENT 2, LENGTH 2
3500-FT SPACING
GAGES 7, 2, AND 8



CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 2
3500-FT SPACING
STATIONS 1 AND 3



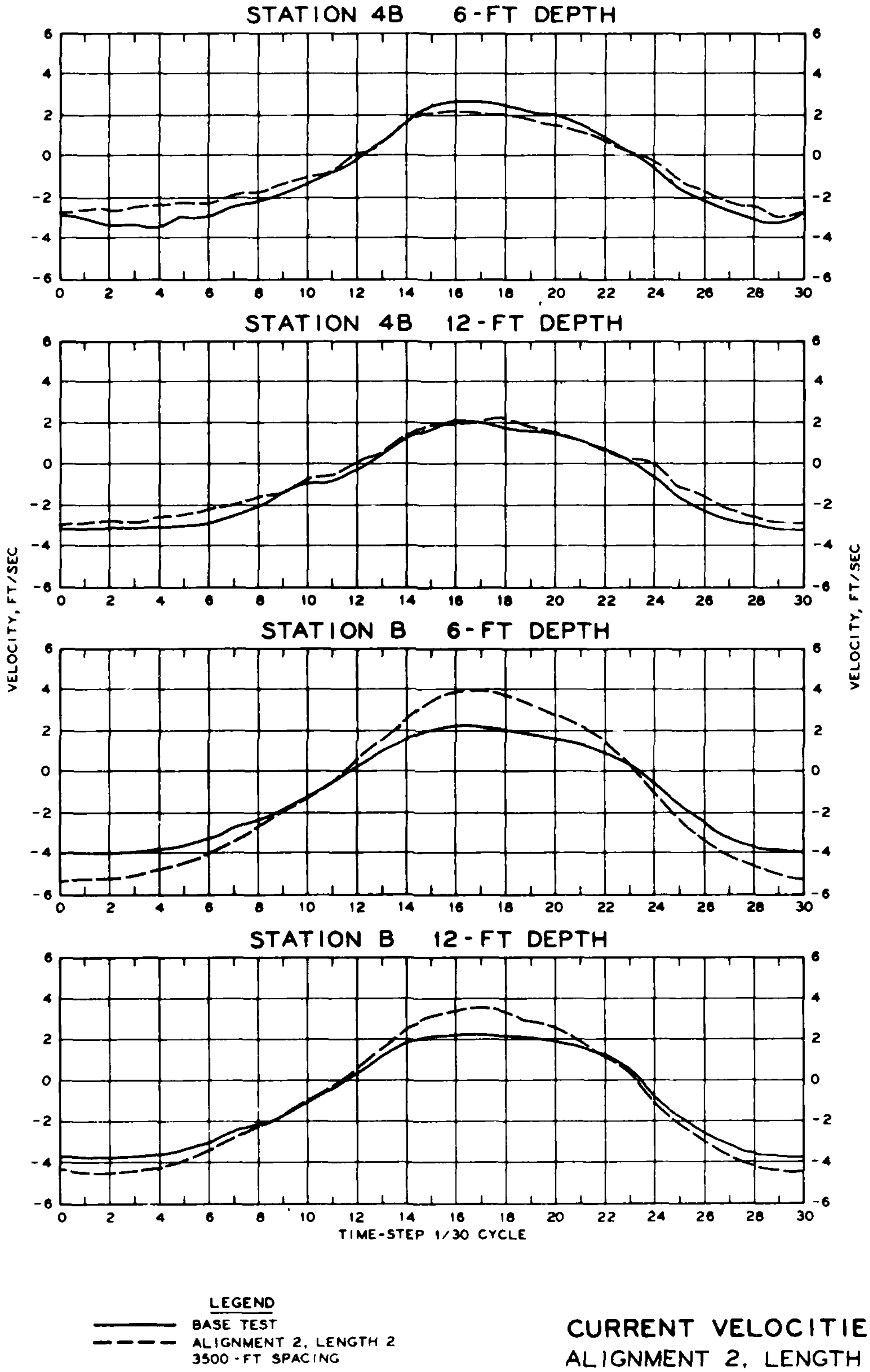
LEGEND

BASE TEST

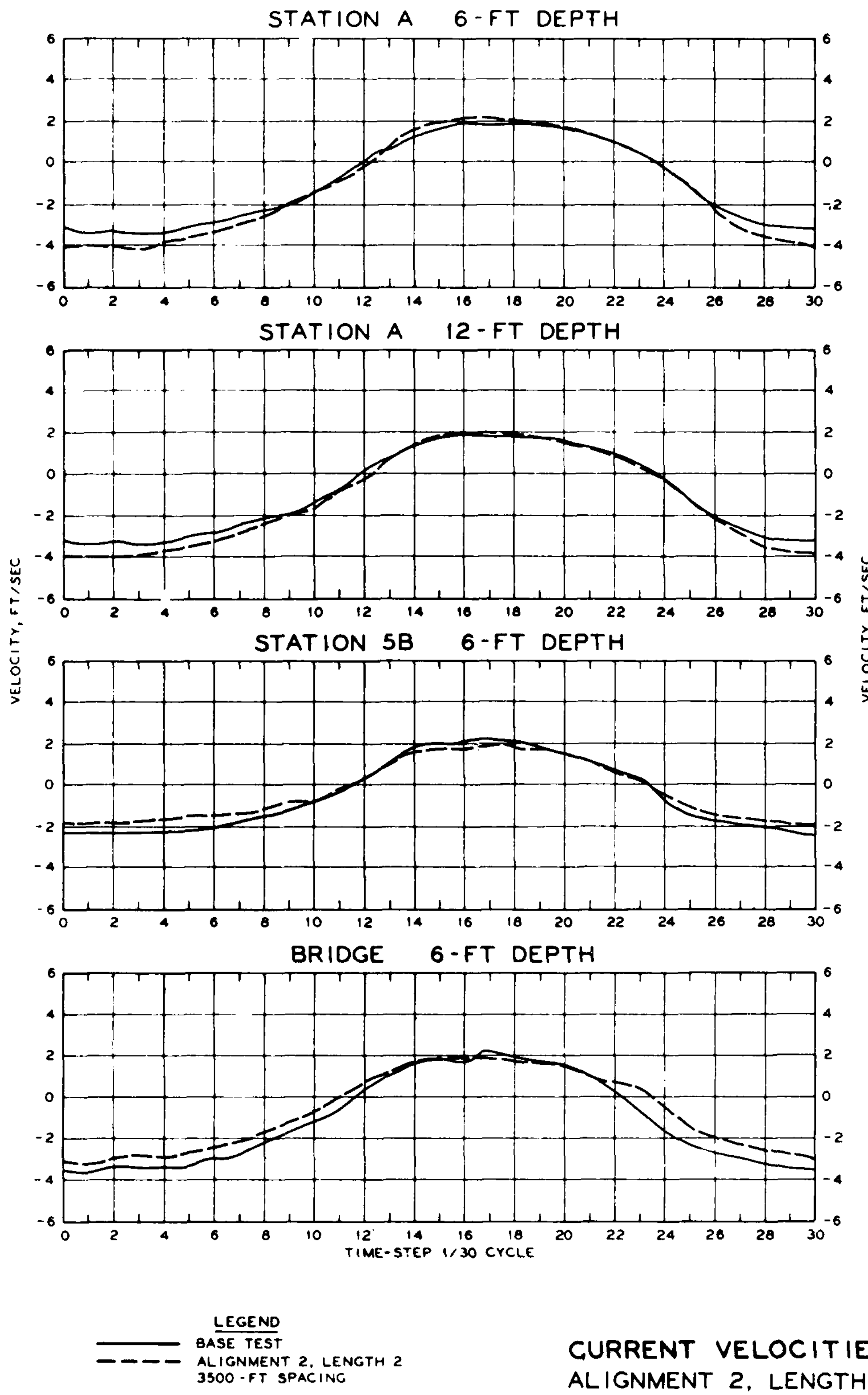
ALIGNMENT 2, LENGTH 2
3500-FT SPACING

CURRENT VELOCITIES

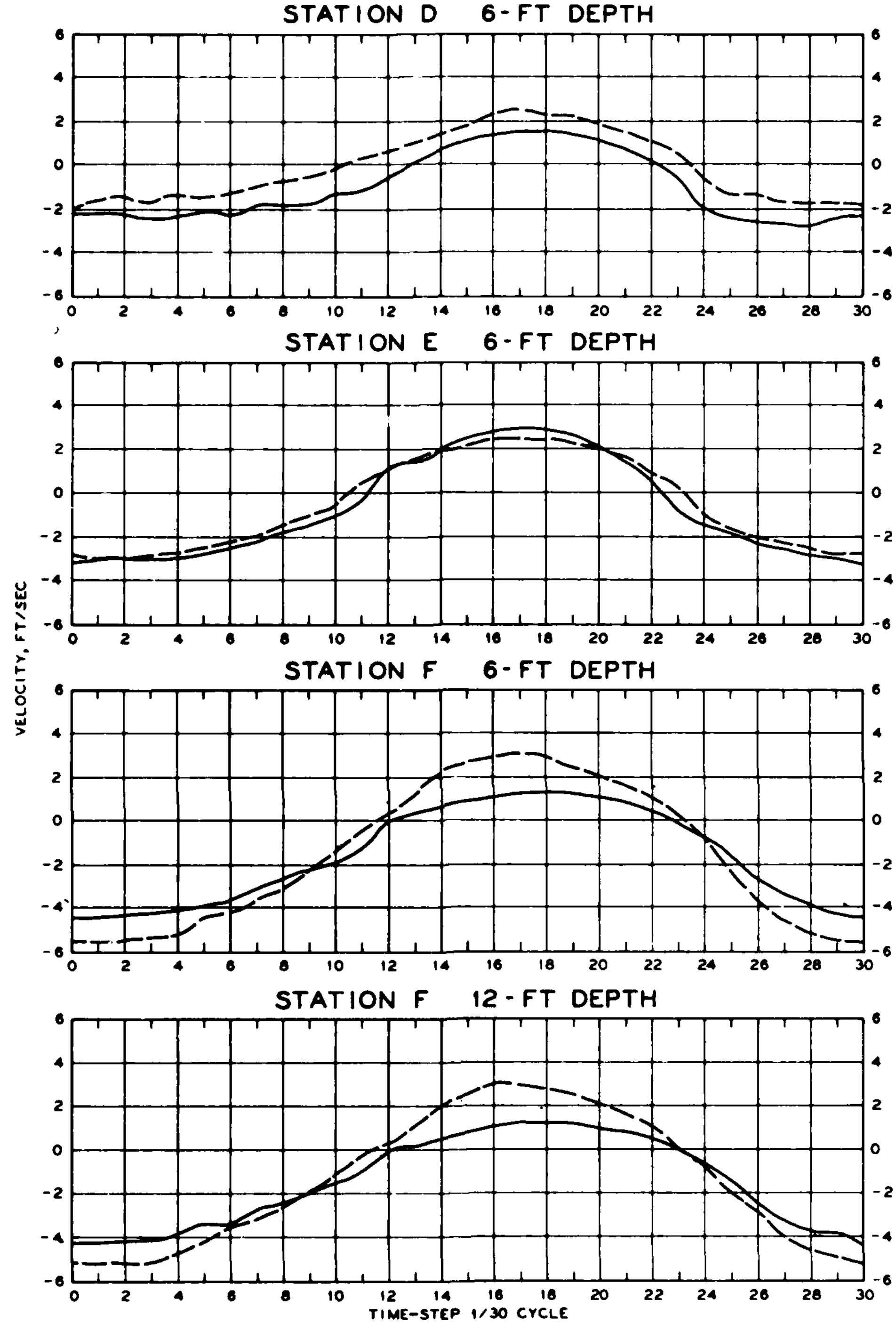
ALIGNMENT 2, LENGTH 2
3500-FT SPACING
STATION 2



CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 2
3500-FT SPACING
STATIONS 4B AND B

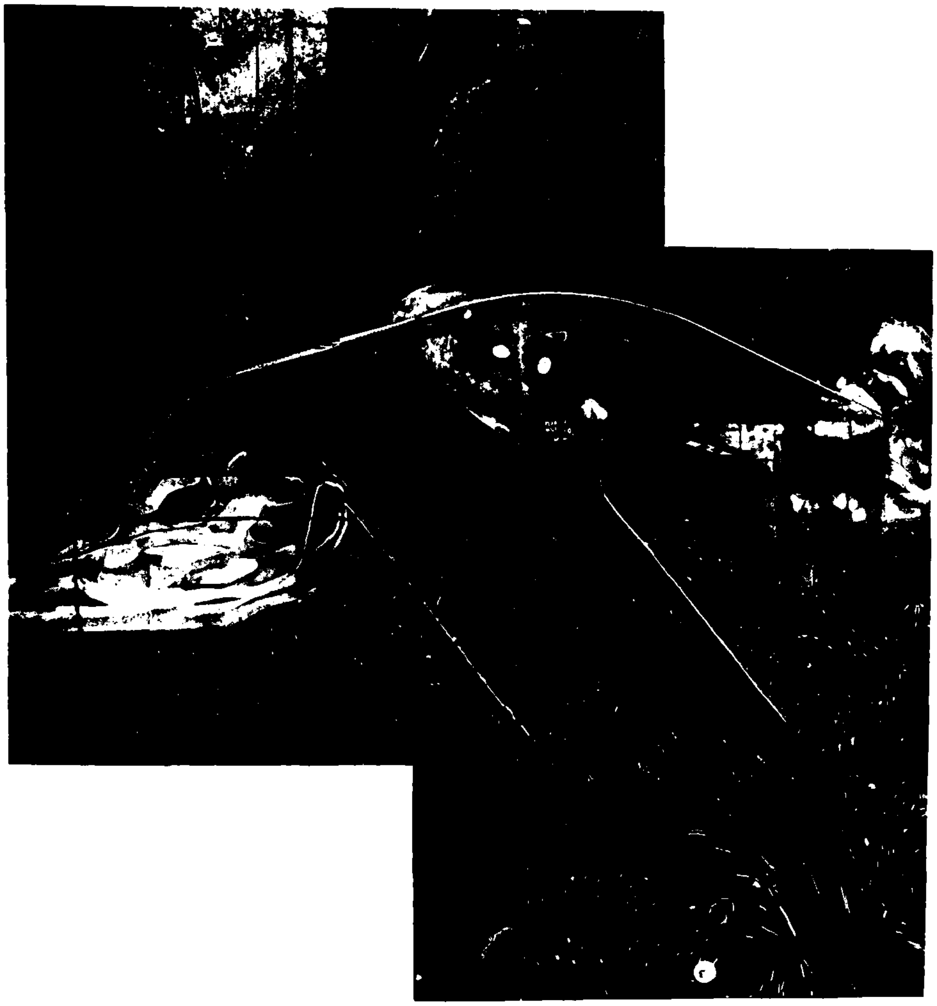


CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 2
3500 - FT SPACING
STATIONS A, 5B, AND BRIDGE



LEGEND
BASE TEST
ALIGNMENT 2, LENGTH 2
3500-FT SPACING

CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 2
3500-FT SPACING
STATIONS D, E, AND F

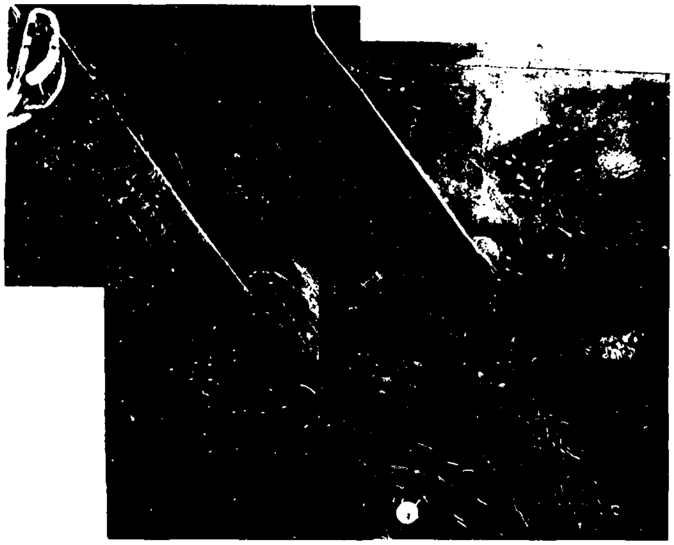


VELOCITY SCALE
5 0 5 10 15 20
FT/SEC

SURFACE CURRENT PHOTOGRAPHS
JETTY ALIGNMENT 2, LENGTH 2
3500-FT SPACING
TIME-STEP 0
STRENGTH OF EBB

VELOCITY SCALE
5 0 5 10 15 20
FT/SEC

SURFACE CURRENT
PHOTOGRAPHS
JETTY ALIGNMENT 2, LENGTH 2
3500-FT SPACING
TIME-STEP 15
STRENGTH OF FLOOD

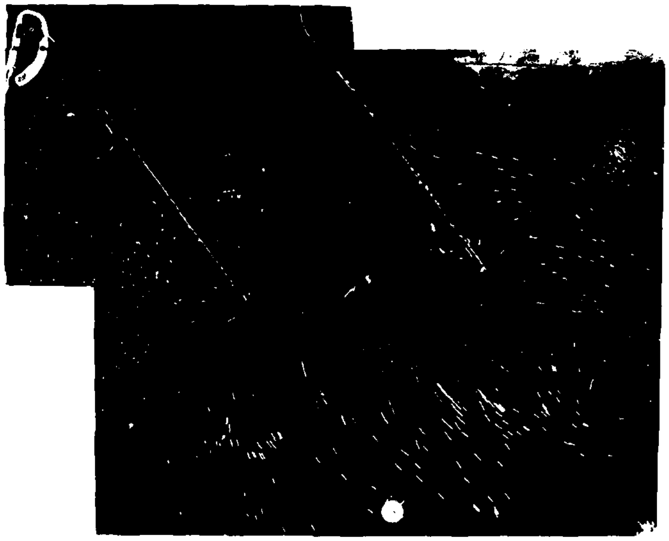


SURFACE CURRENT PHOTOGRAPHS

SIMULATED STORM SURGE OF 12 SEPTEMBER 1960

JETTY ALIGNMENT 2, LENGTH 2

3500-FT SPACING



VELOCITY SCALE

10 0 10 20 30 40

FT/SEC

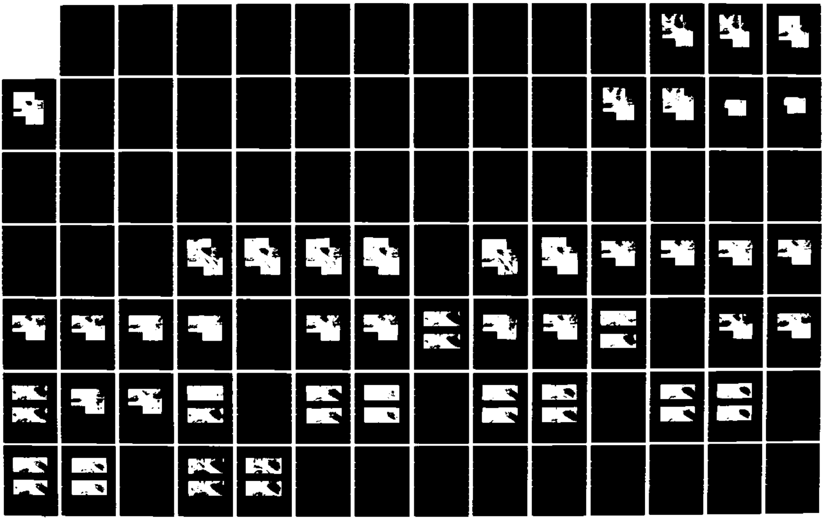
SURFACE CURRENT PHOTOGRAPHS

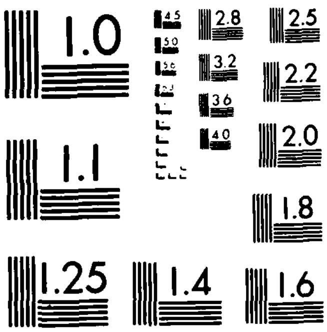
SIMULATED STORM SURGE OF 17 MARCH 1962

JETTY ALIGNMENT 2, LENGTH 2
3500-FT SPACING

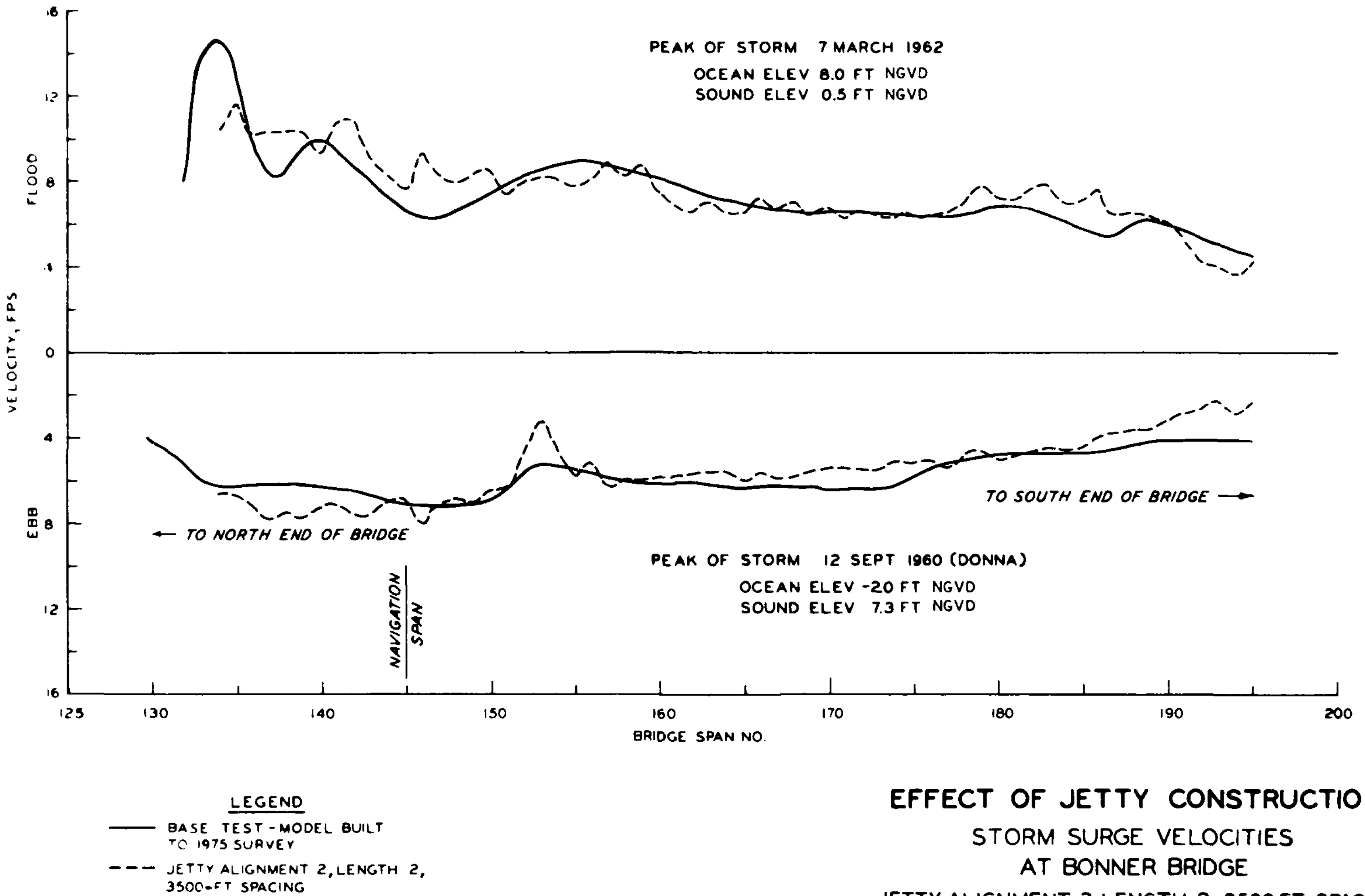
AD-A131 999 HYDRAULIC MODEL INVESTIGATION: FUNCTIONAL DESIGN OF CONTROL STRUCTURES FO..(U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS HYDRA.. 3/6

UNCLASSIFIED N W HOLLYFIELD ET AL. JUN 83 F/G 8/3 NL





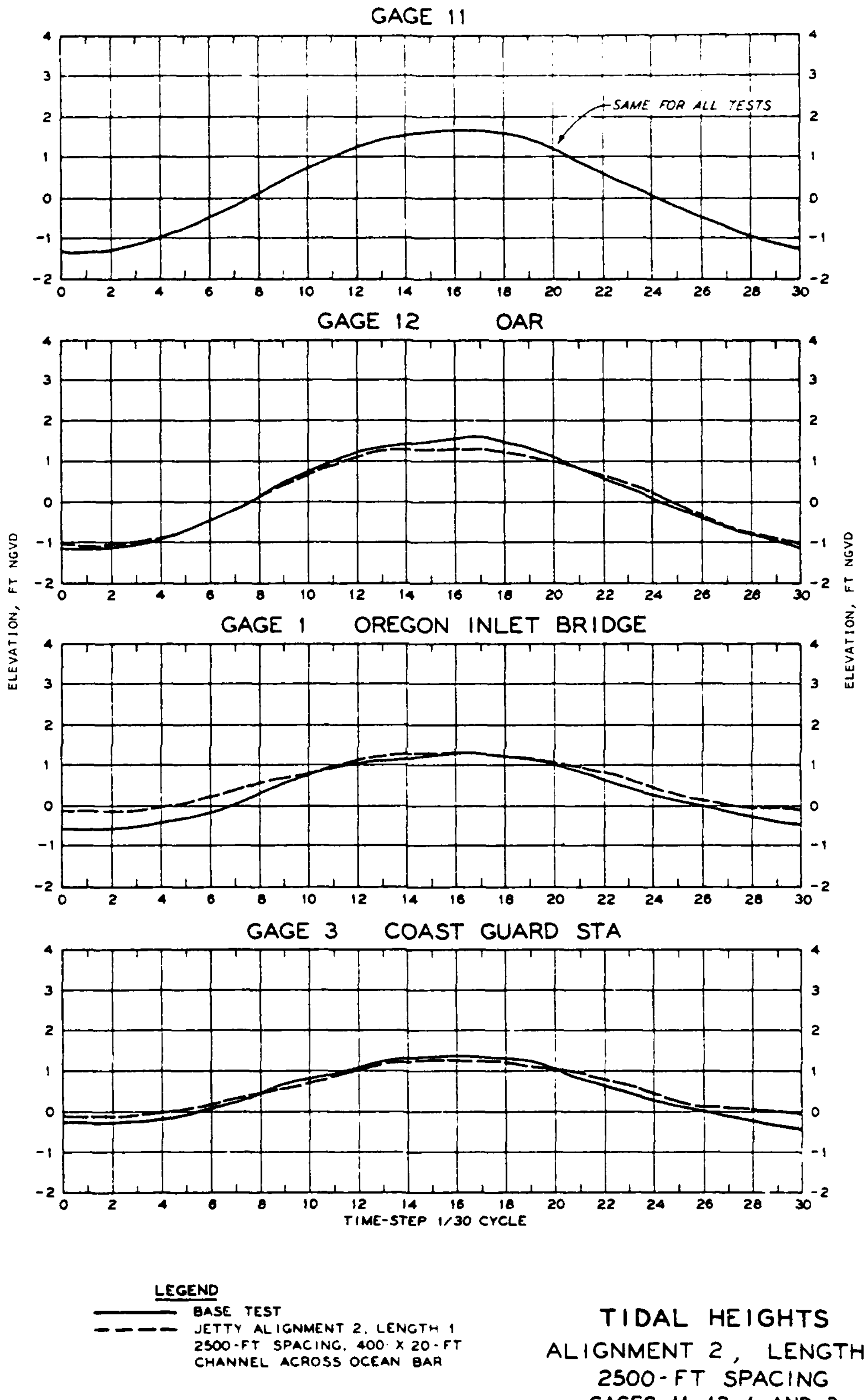
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A



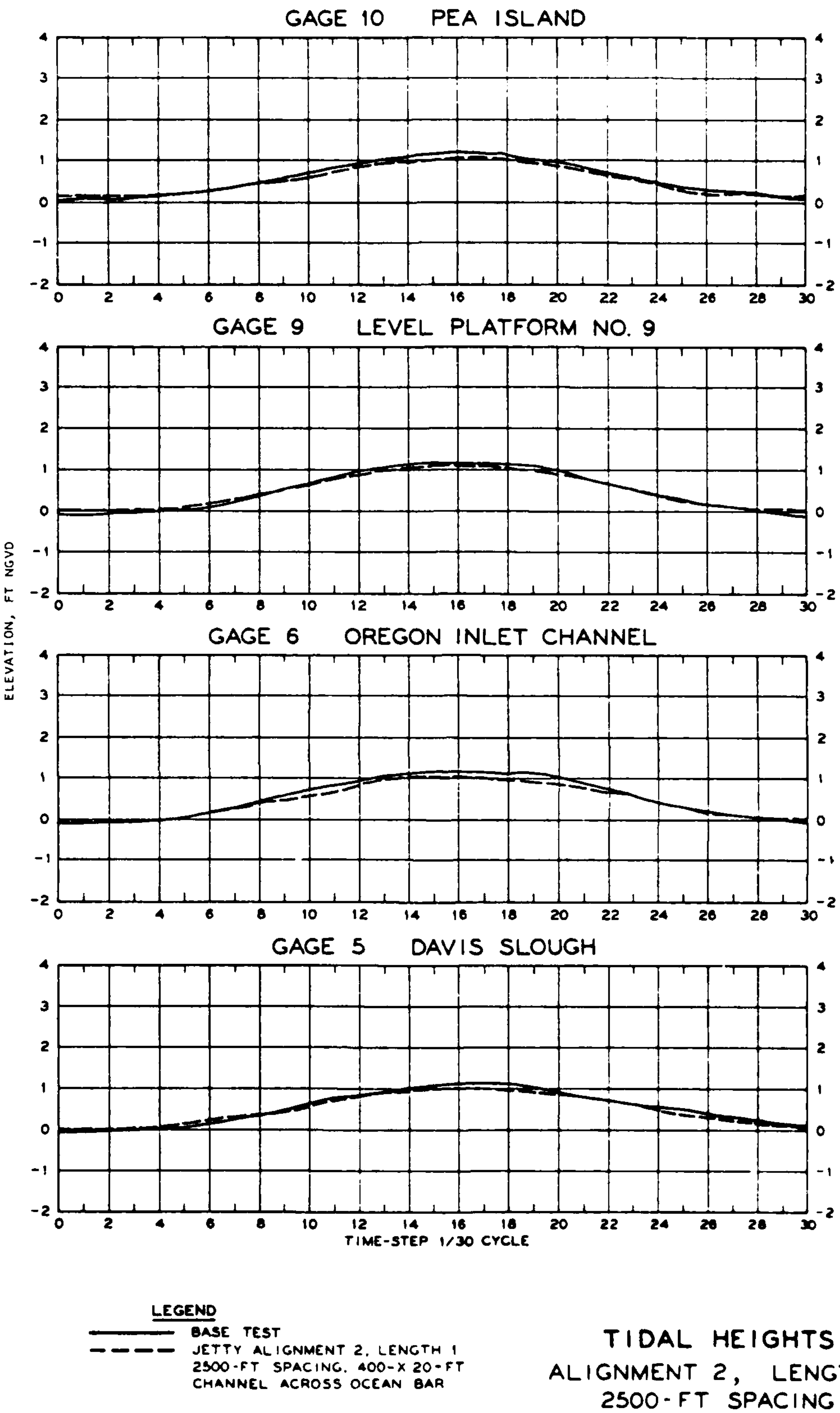
EFFECT OF JETTY CONSTRUCTION

STORM SURGE VELOCITIES
AT BONNER BRIDGE

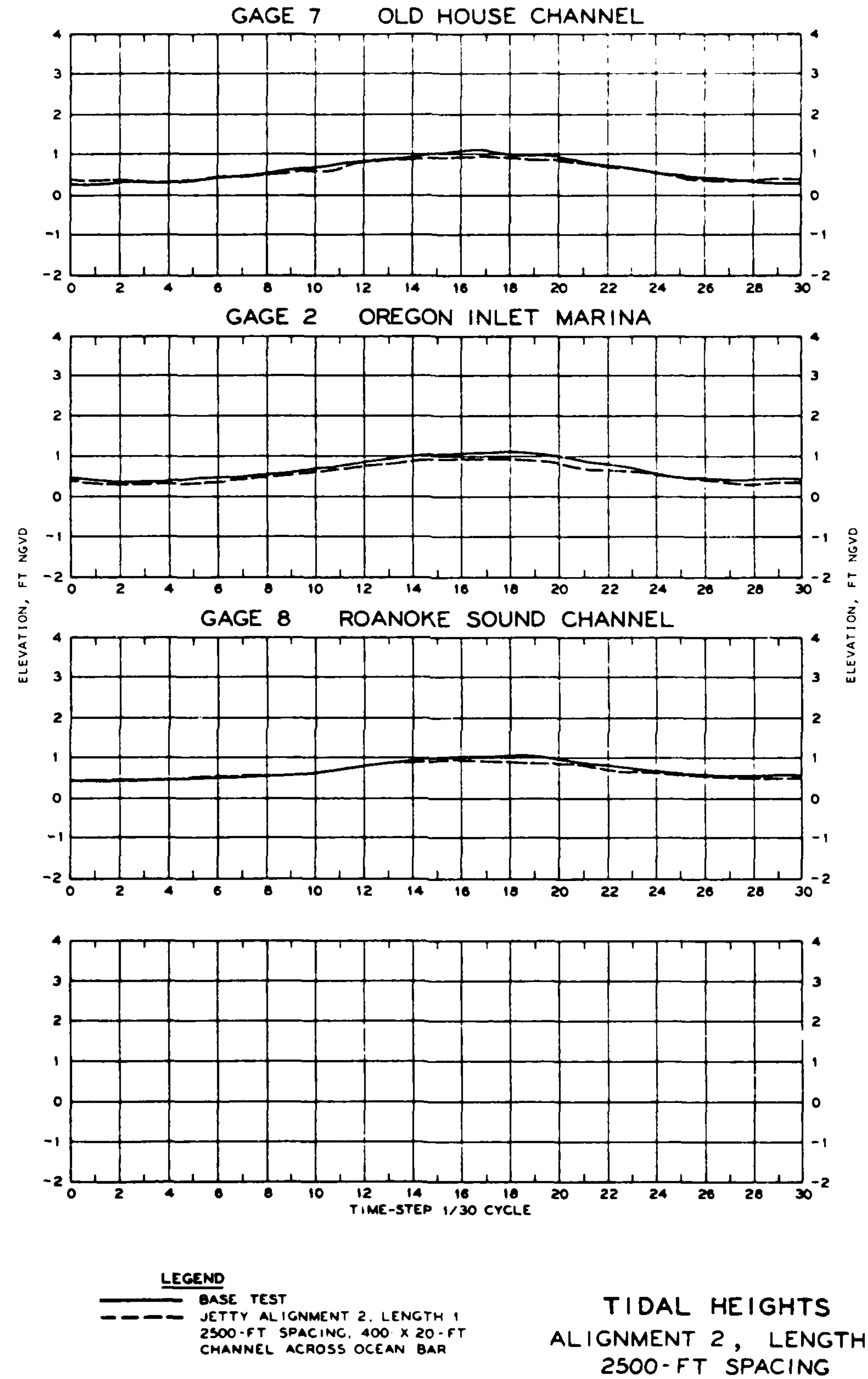
JETTY ALIGNMENT 2, LENGTH 2 3500-FT SPACING



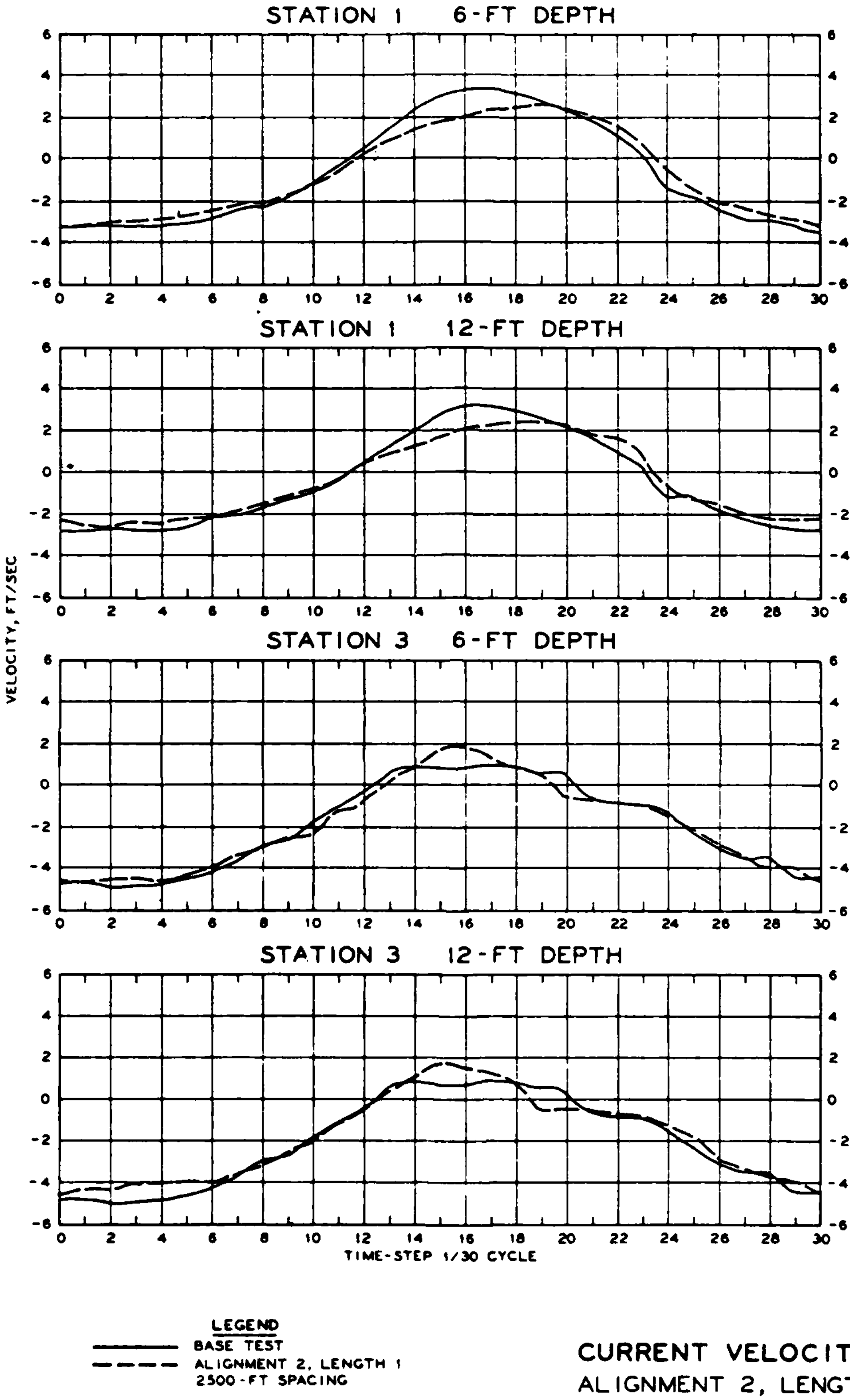
TIDAL HEIGHTS
ALIGNMENT 2, LENGTH 1
2500-FT SPACING
GAGES 11, 12, 1, AND 3



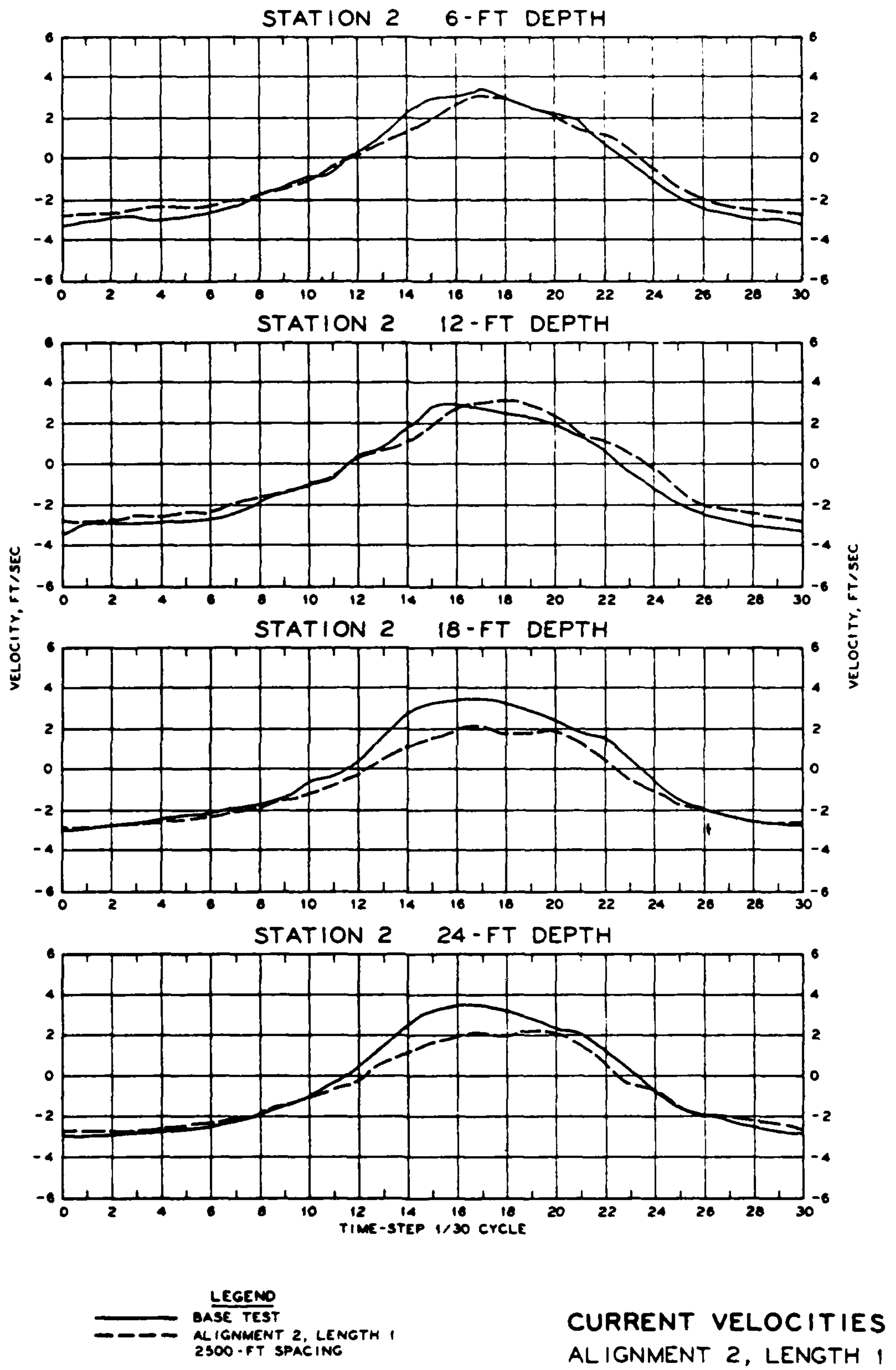
TIDAL HEIGHTS
ALIGNMENT 2, LENGTH 1
2500-FT SPACING
GAGES 10, 9, 6, AND 5



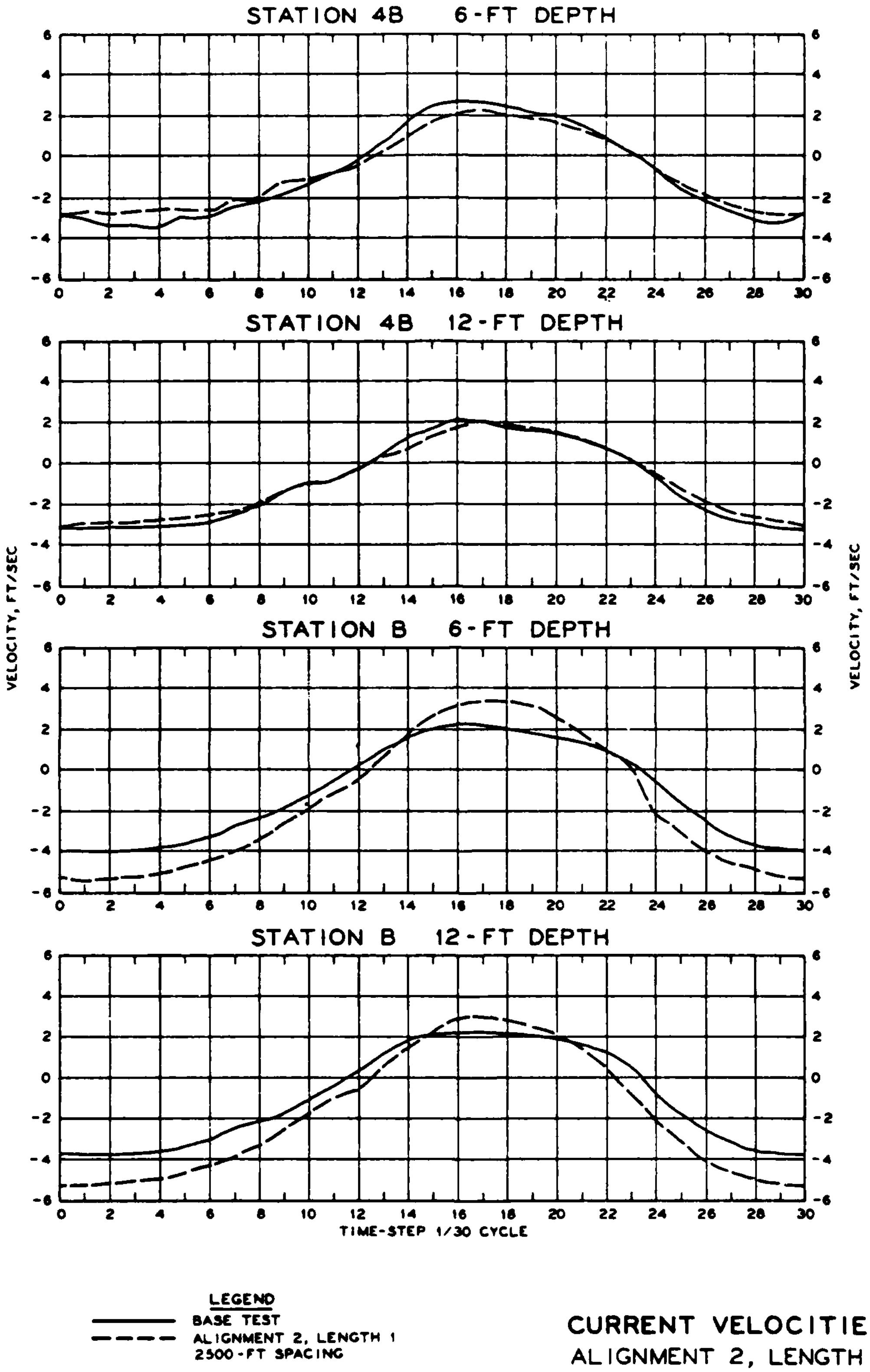
TIDAL HEIGHTS
ALIGNMENT 2, LENGTH 1
2500-FT SPACING
GAGES 7, 2, AND 8



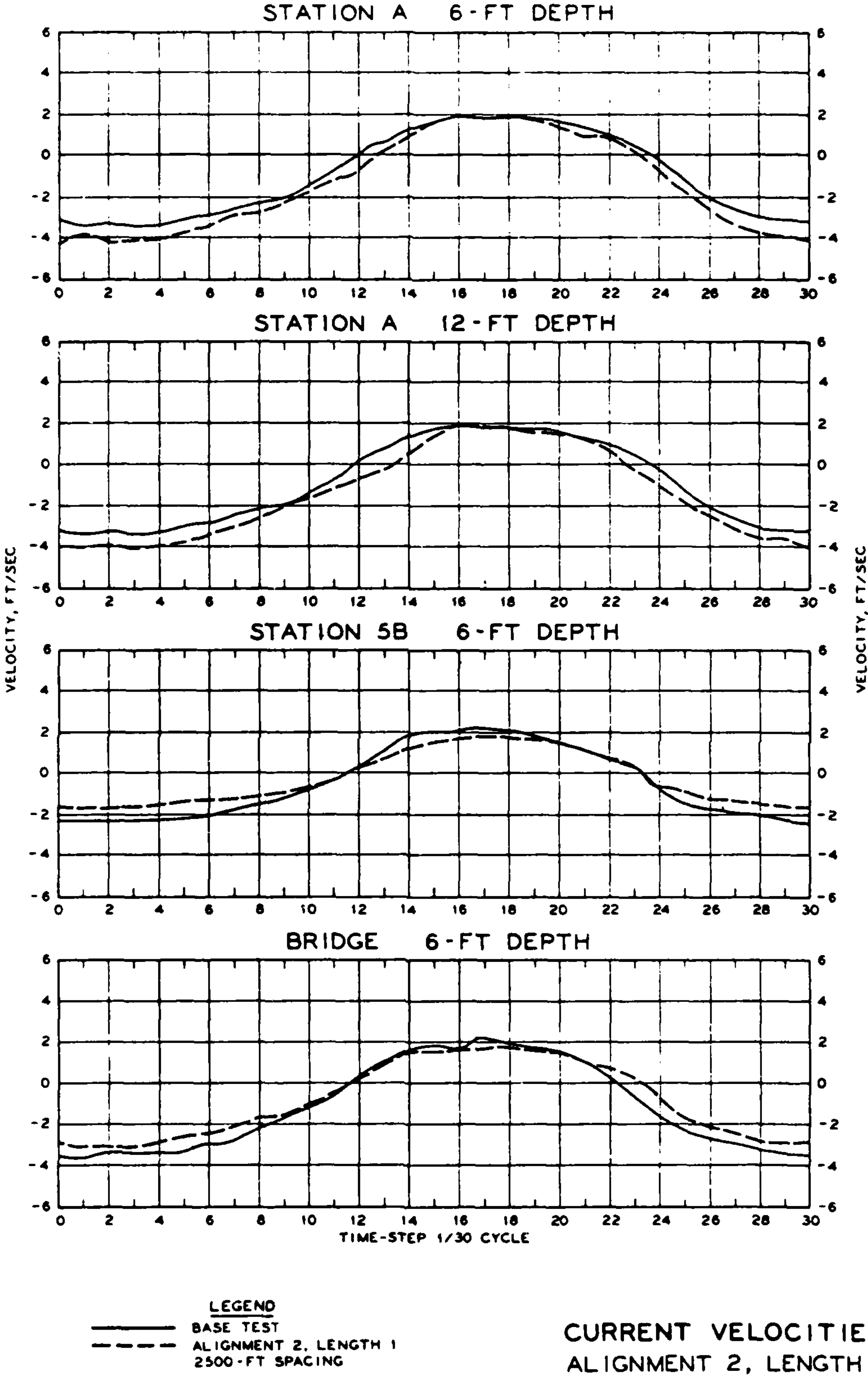
CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 1
2500-FT SPACING
STATIONS 1 AND 3



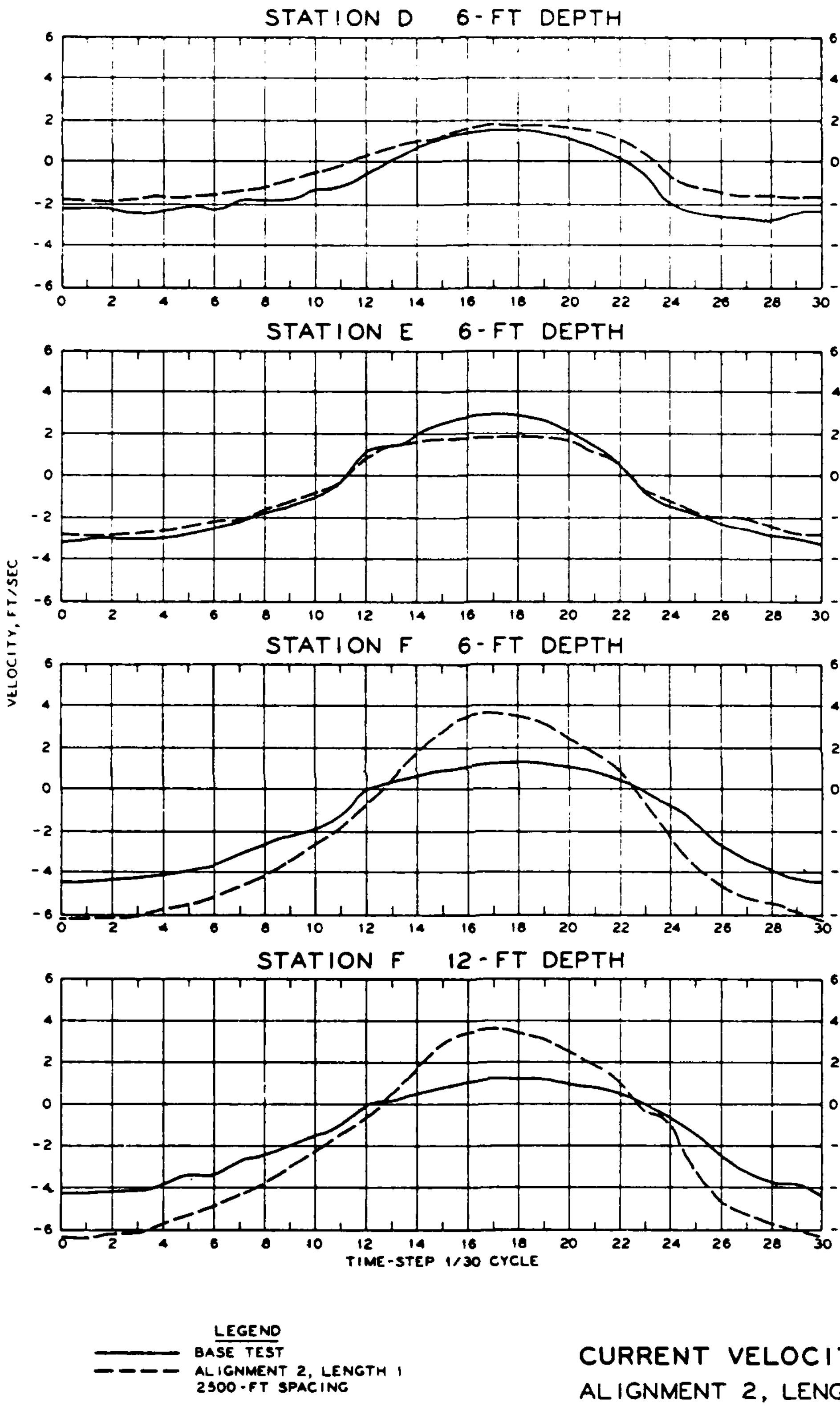
CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 1
2500-FT SPACING
STATION 2



CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 1
2500-FT SPACING
STATIONS 4B, AND B



CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 1
2500-FT SPACING
STATIONS A, 5B, AND BRIDGE



CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 1
2500-FT SPACING
STATIONS D, E, AND F

SURFACE CURRENT PHOTOGRAPHS

JETTY ALIGNMENT 2, LENGTH 1
2500-FT SPACING
TIME-STEP 0
STRENGTH OF EBB

VELOCITY SCALE

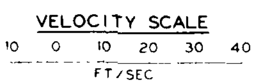
5 0 5 10 15 20

FT/SEC

SURFACE CURRENT PHOTOGRAPHS

JETTY ALIGNMENT 2, LENGTH 1
2500-FT SPACING

TIME-STEP 15
STRENGTH OF FLOOD



SURFACE CURRENT
PHOTOGRAPHS

SIMULATED STORM SURGE OF
12 SEPTEMBER 1960

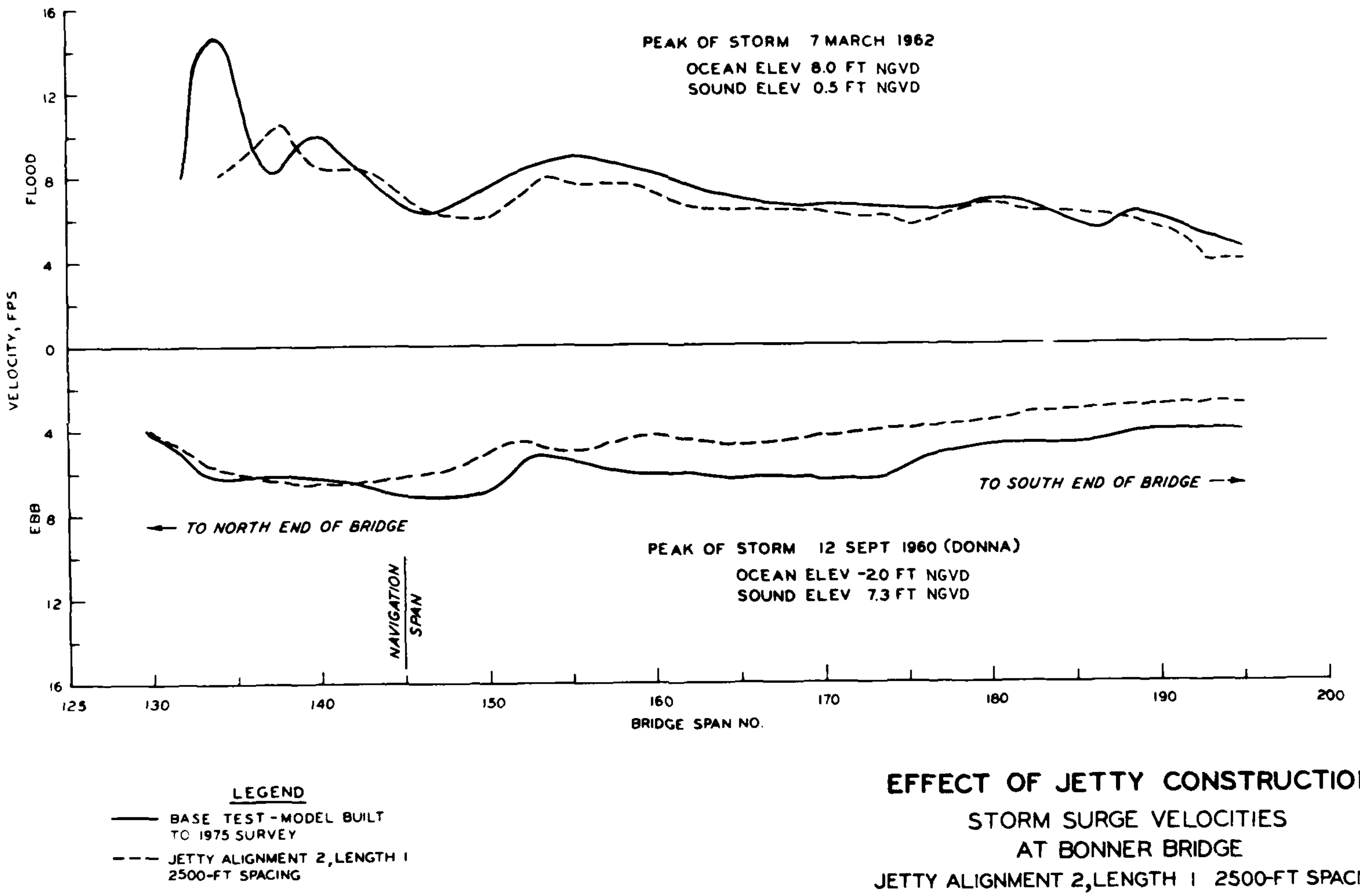
JETTY ALIGNMENT 2, LENGTH 1
2500-FT SPACING
EBB

VELOCITY SCALE

10 0 10 20 30 40

FT/SEC

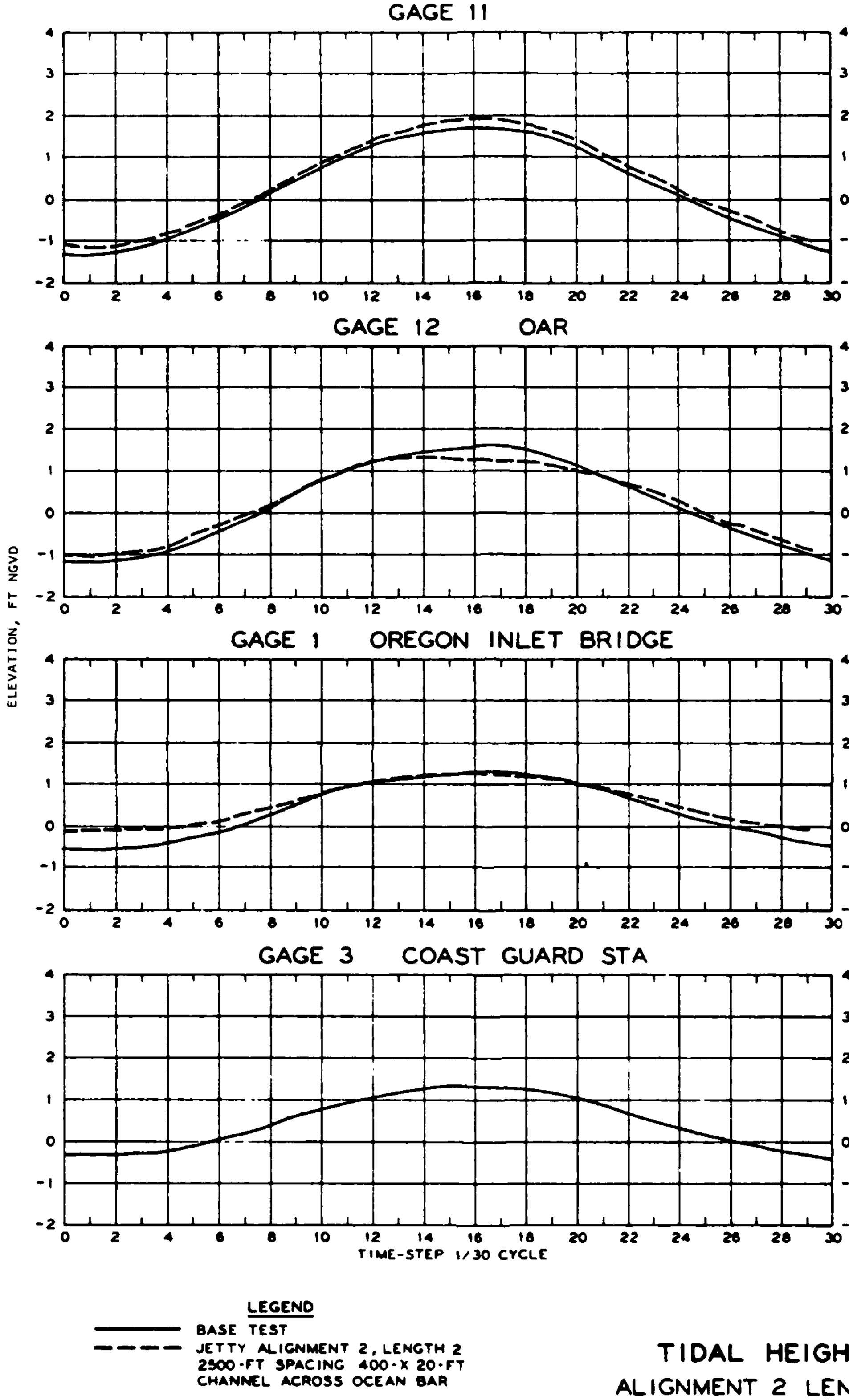
SURFACE CURRENT
PHOTOGRAPHS
SIMULATED STORM SURGE OF
7 MARCH 1962
JETTY ALIGNMENT 2, LENGTH 1
2500-FT SPACING



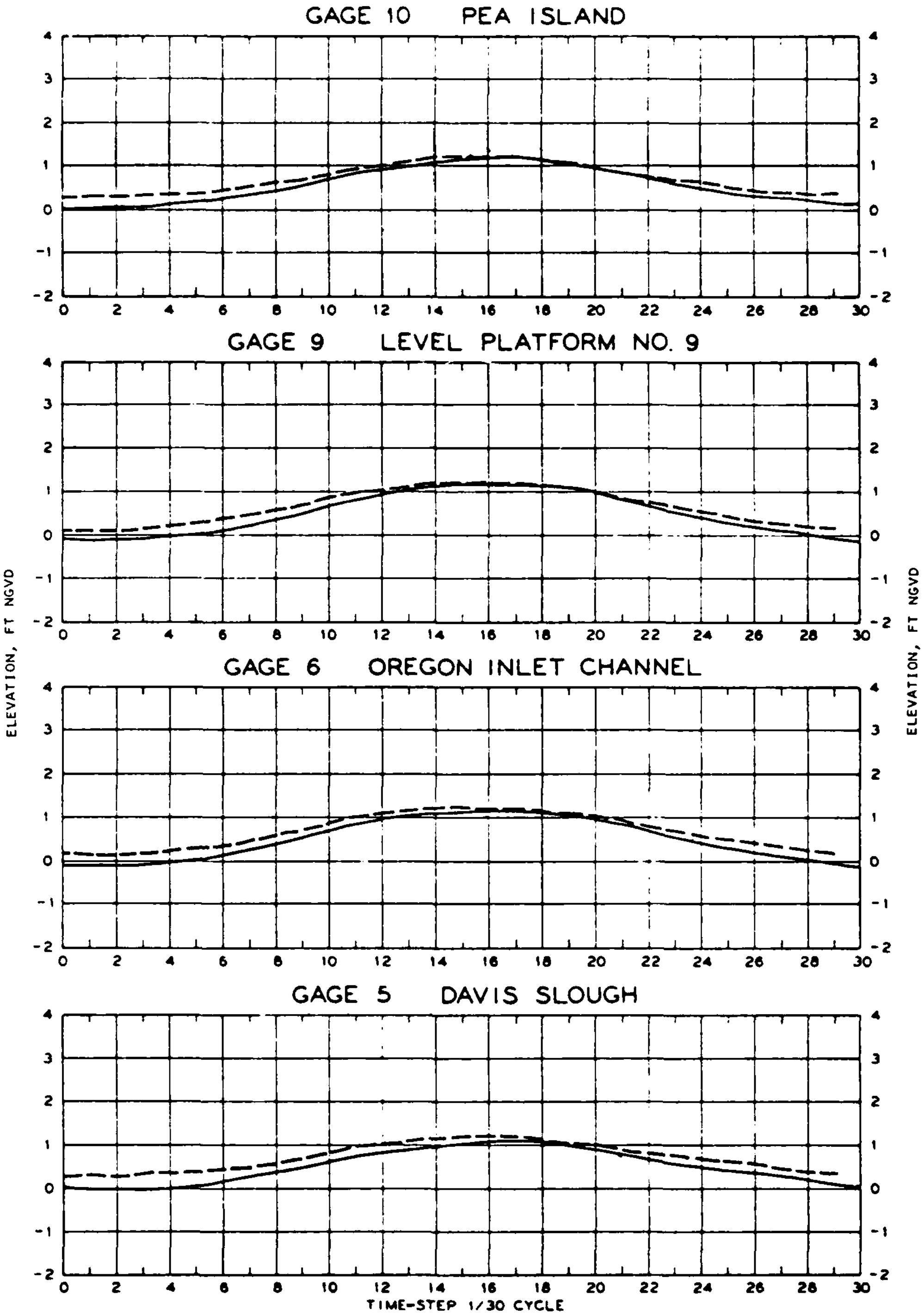
EFFECT OF JETTY CONSTRUCTION

STORM SURGE VELOCITIES
AT BONNER BRIDGE
JETTY ALIGNMENT 2, LENGTH 1 2500-FT SPACING

PLATE 108



TIDAL HEIGHTS
ALIGNMENT 2 LENGTH 2
2500-FT, SPACING
GAGES 11, 12, 1, AND 3

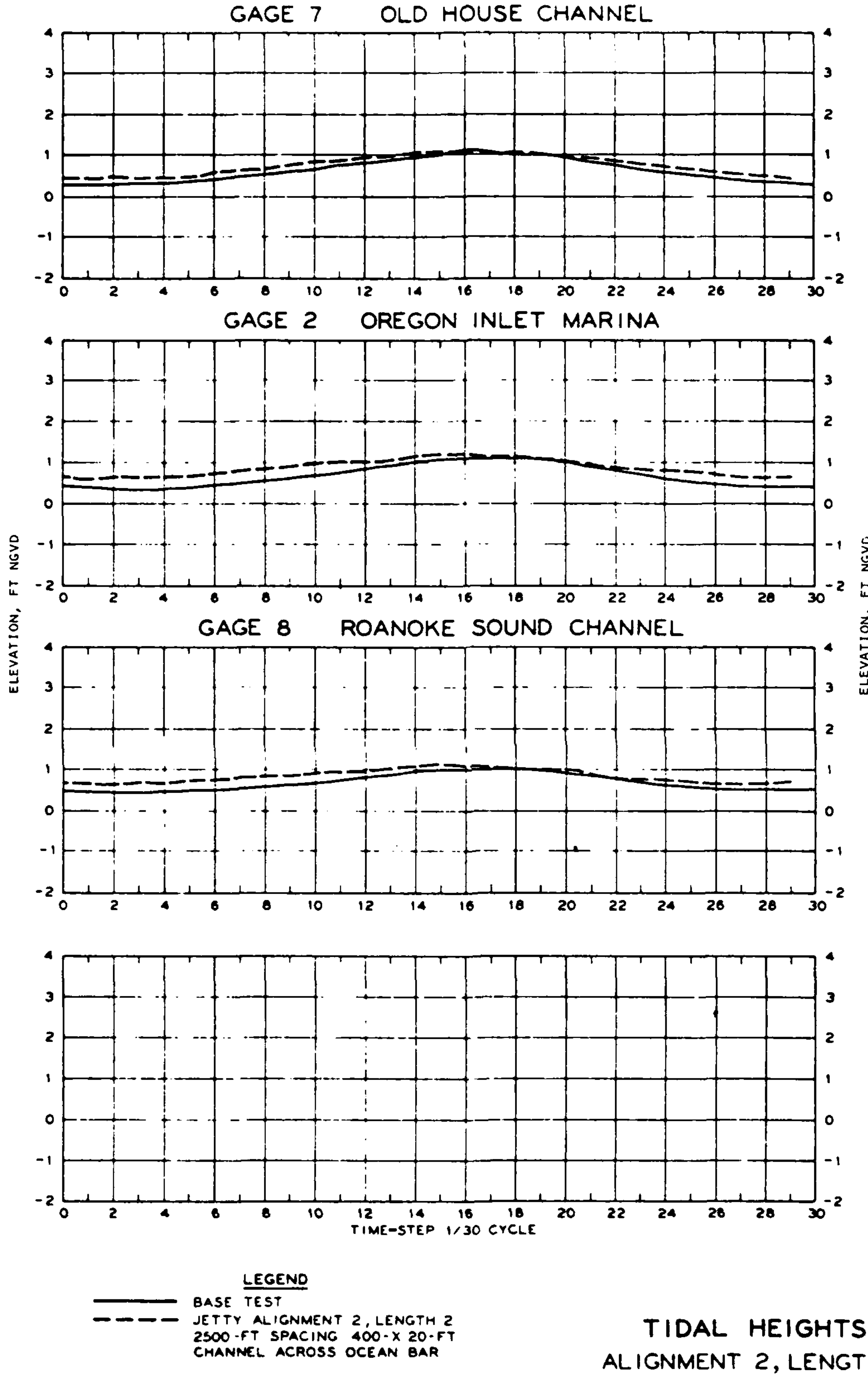


LEGEND

——— BASE TEST

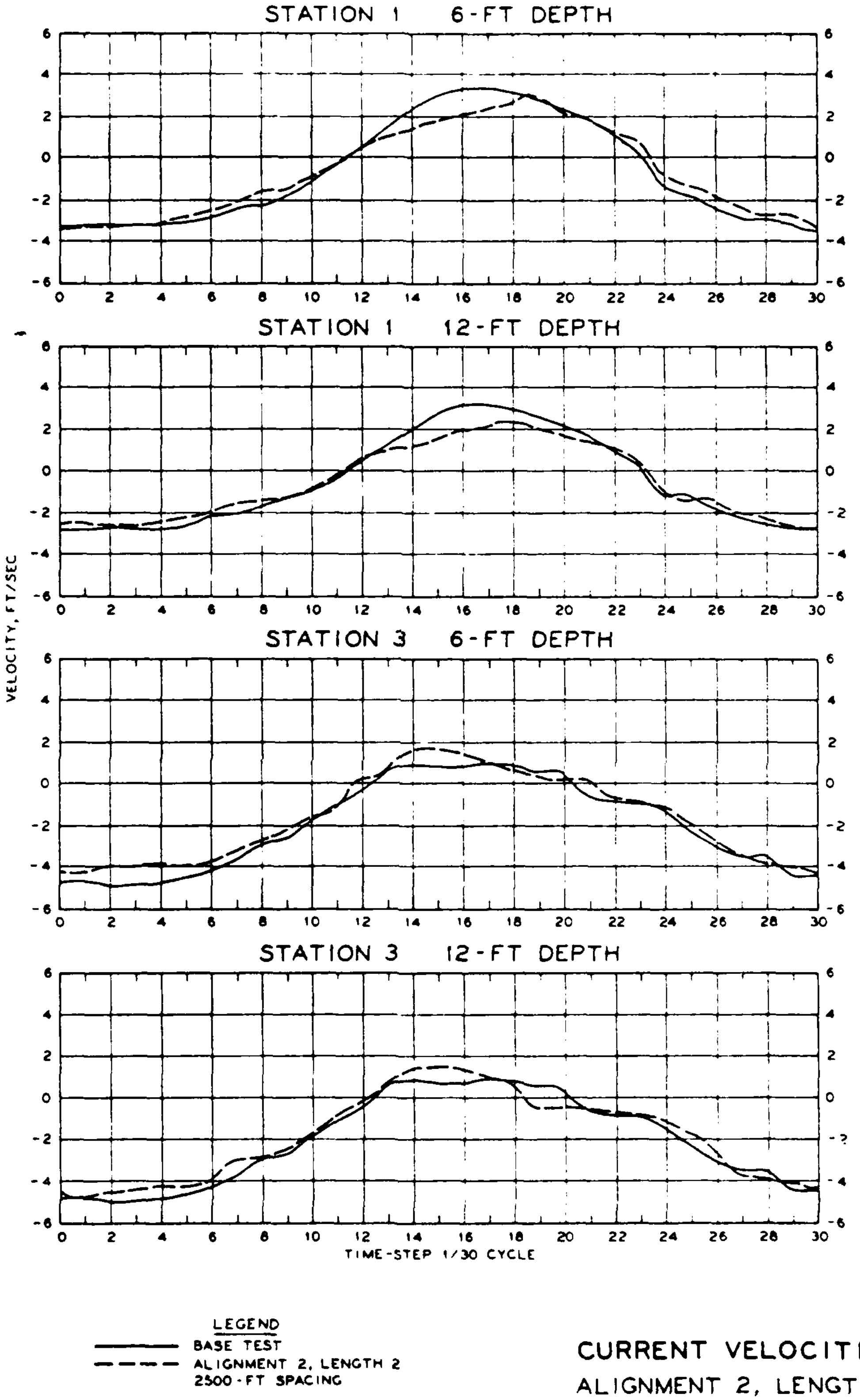
– – – JETTY ALIGNMENT 2, LENGTH 2 2500-FT SPACING 400-X 20-FT CHANNEL ACROSS OCEAN BAR

TIDAL HEIGHTS
ALIGNMENT 2, LENGTH 2
2500-FT SPACING
GAGES 10, 9, 6, AND 5

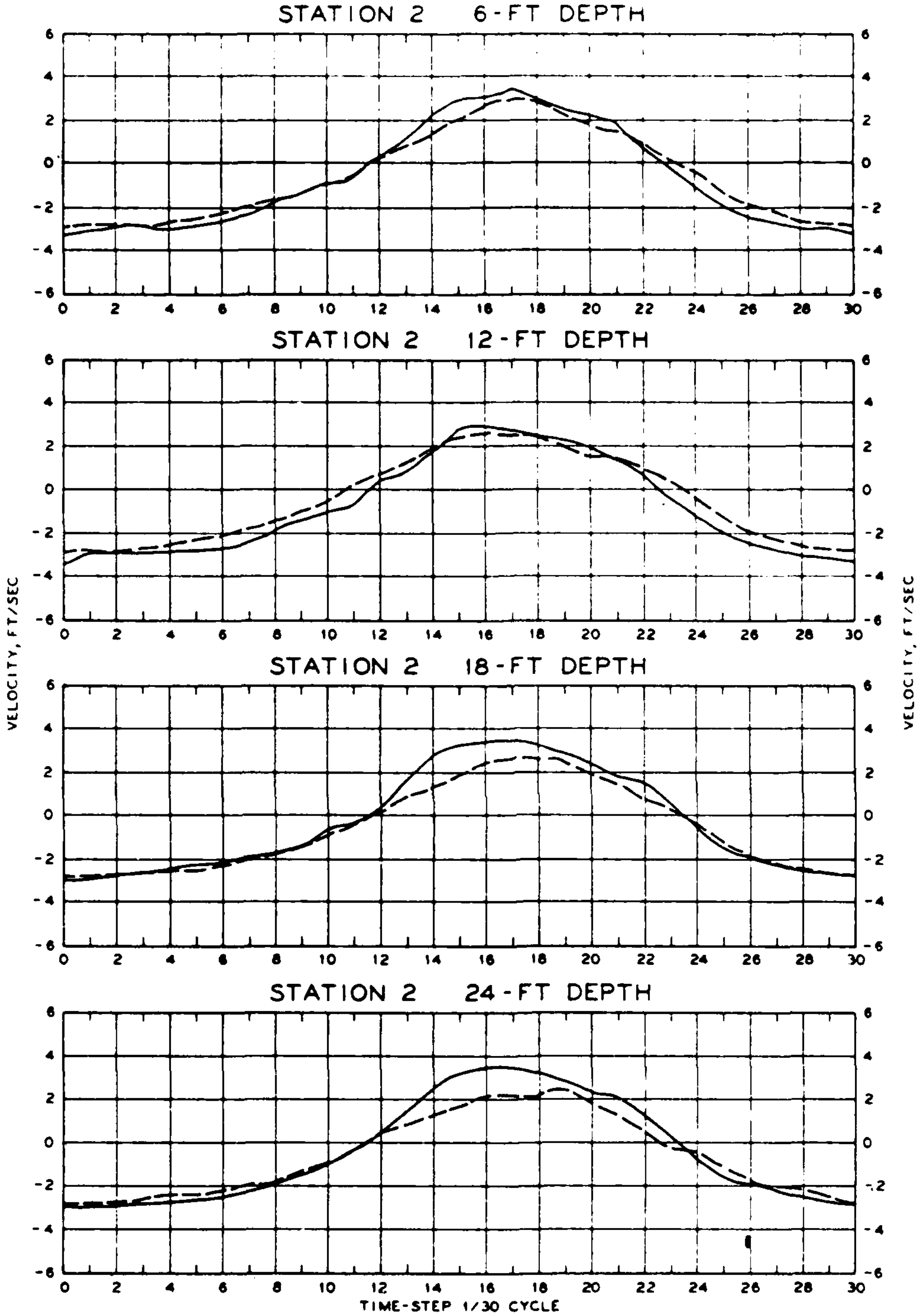


TIDAL HEIGHTS

ALIGNMENT 2, LENGTH 2
2500-FT SPACING
GAGES 7, 2, AND 8



CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 2
2500 - FT SPACING
STATIONS 1 AND 3

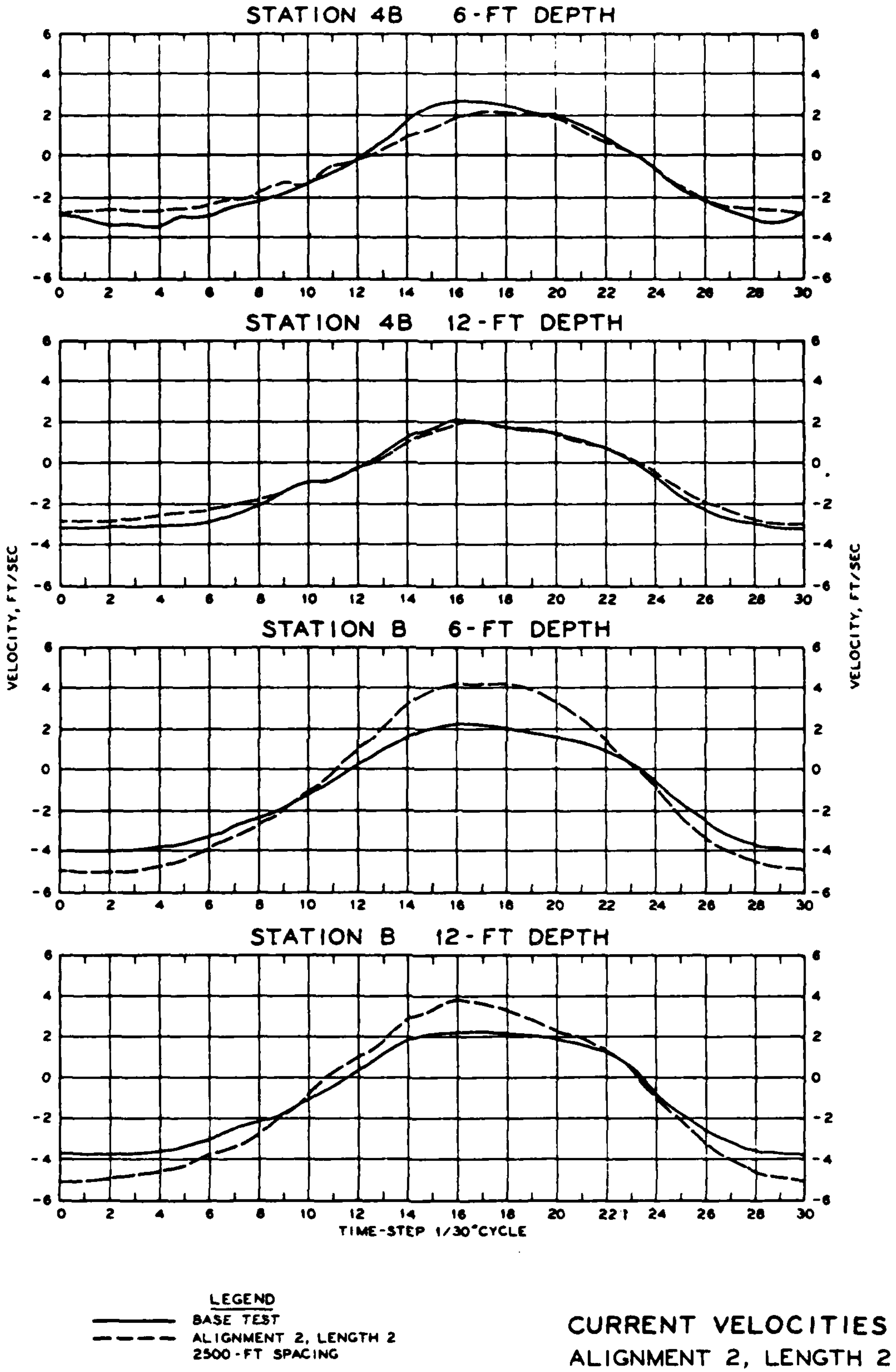


LEGEND

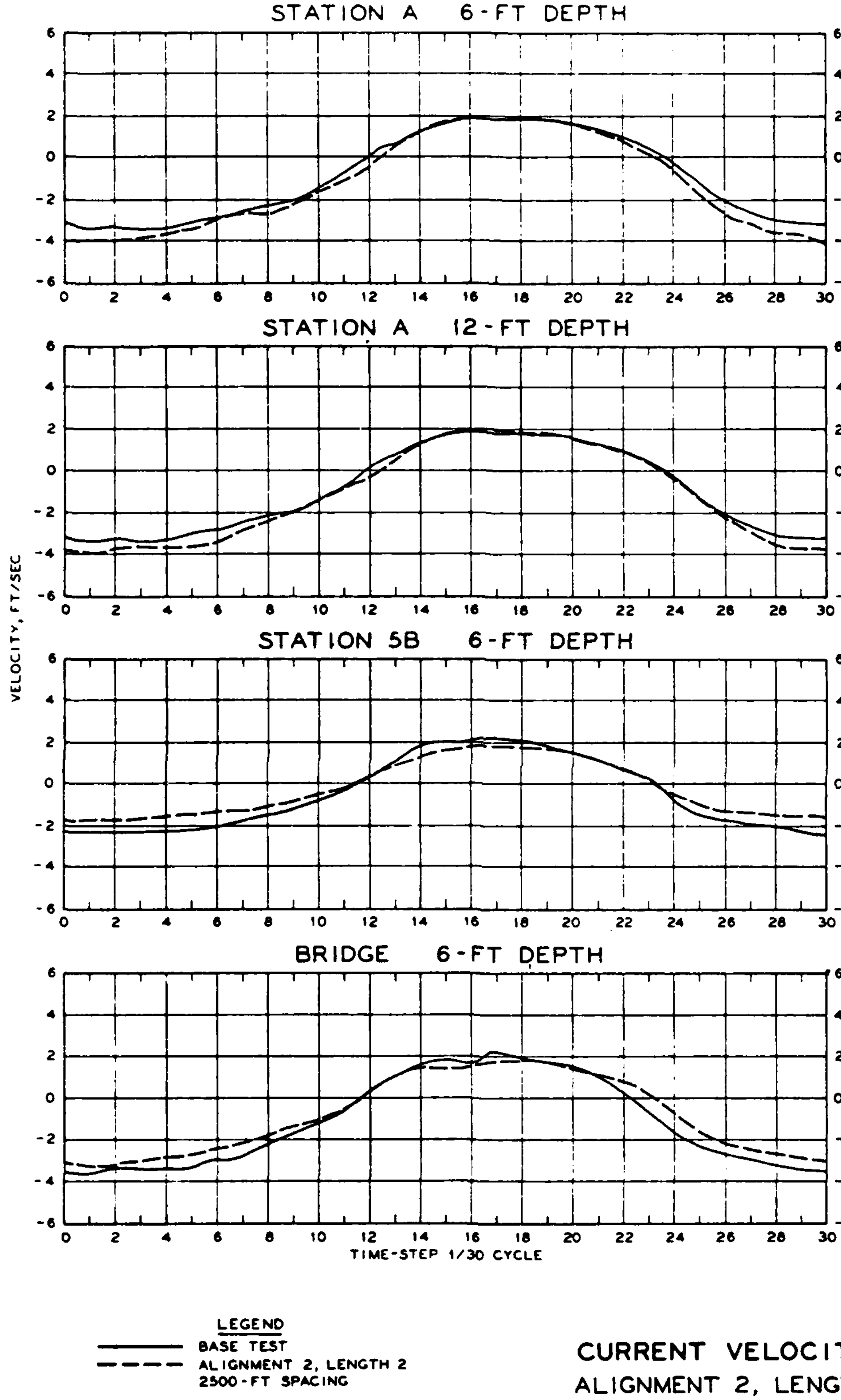
—— BASE TEST

– – – ALIGNMENT 2, LENGTH 2 2500-FT SPACING

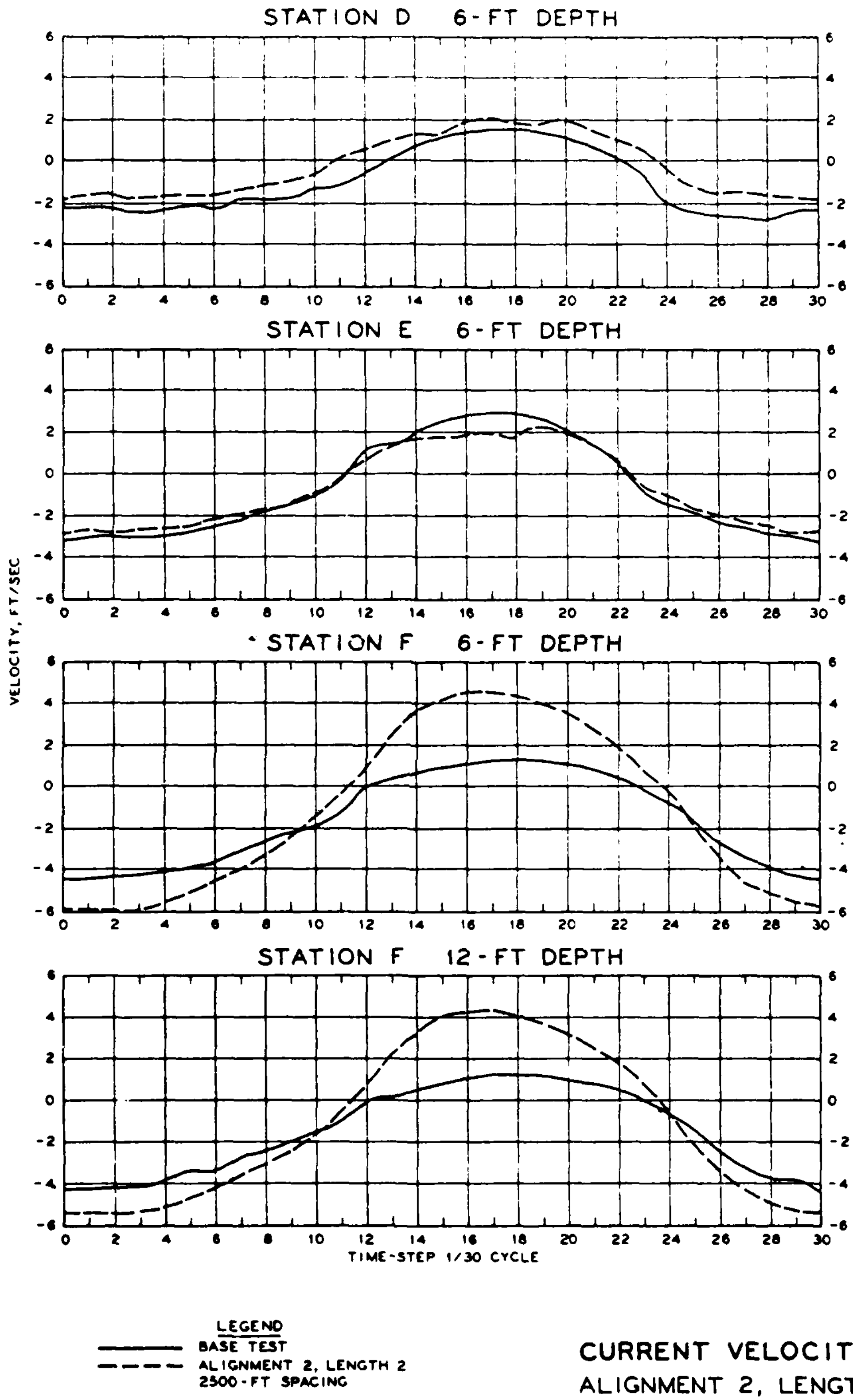
CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 2
2500 - FT SPACING
STATION 2



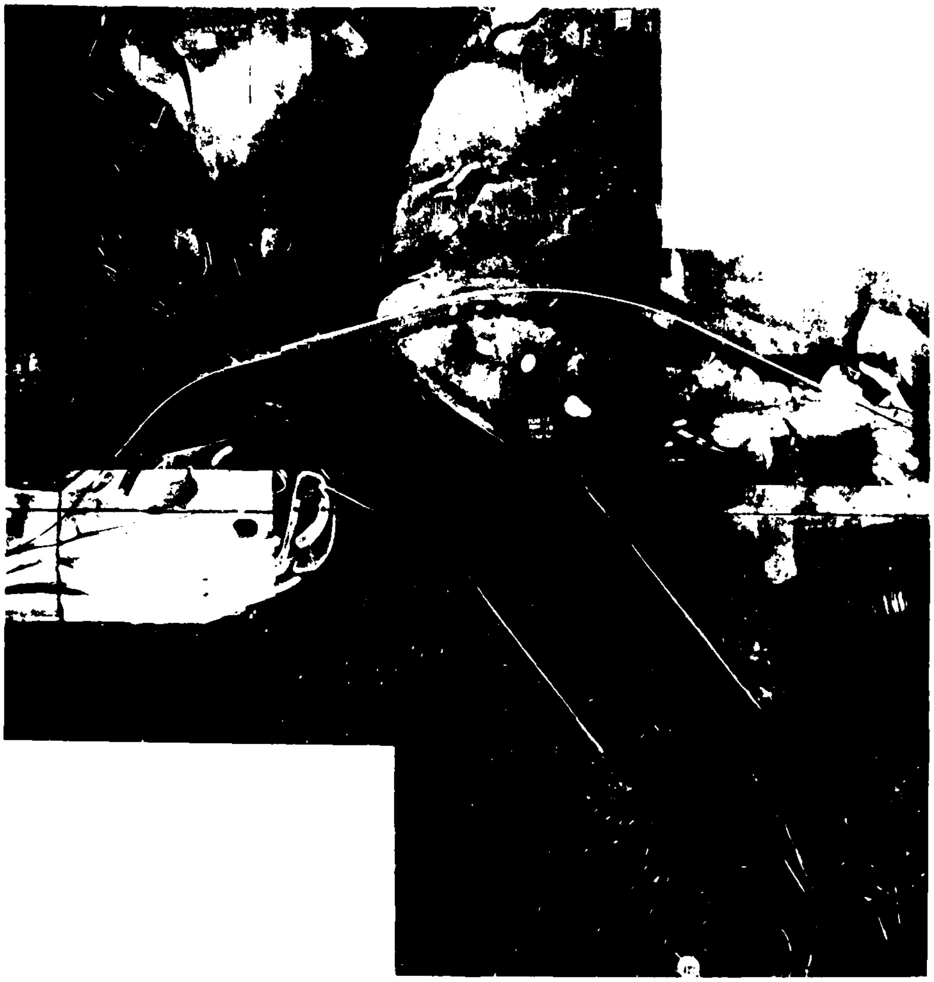
CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 2
2500 - FT SPACING
STATIONS 4B, AND B



CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 2
2500-FT SPACING
STATIONS A, 5B, AND BRIDGE



CURRENT VELOCITIES
ALIGNMENT 2, LENGTH 2
2500-FT SPACING
STATIONS D, E, AND F



VELOCITY SCALE
5 0 5 10 15 20
FT/SEC

SURFACE CURRENT
PHOTOGRAPHS
JETTY ALIGNMENT 2, LENGTH 2
2500-FT SPACING
TIME-STEP 0
STRENGTH OF EBB

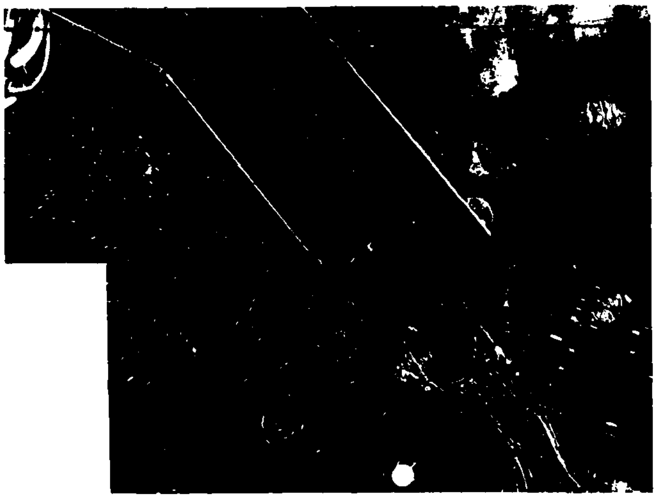
VELOCITY SCALE

5 0 5 10 15 20

FT/SEC

SURFACE CURRENT PHOTOGRAPHS

JETTY ALIGNMENT 2, LENGTH 2
2500-FT SPACING
TIME-STEP 15
STRENGTH OF FLOOD

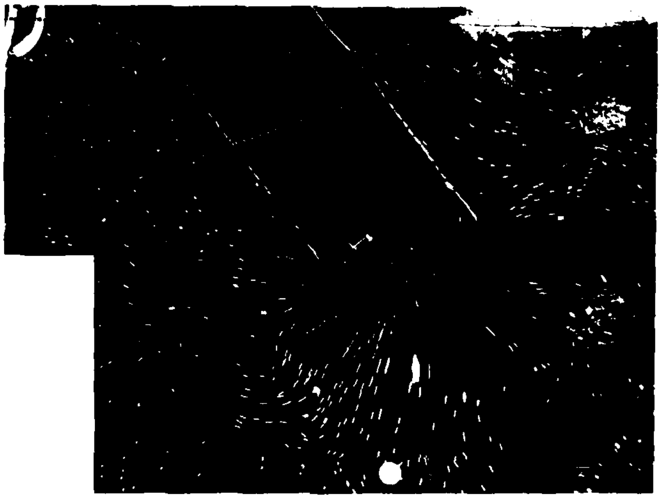


VELOCITY SCALE
10 0 10 20 30 40
FT / SEC

SURFACE CURRENT PHOTOGRAPHS

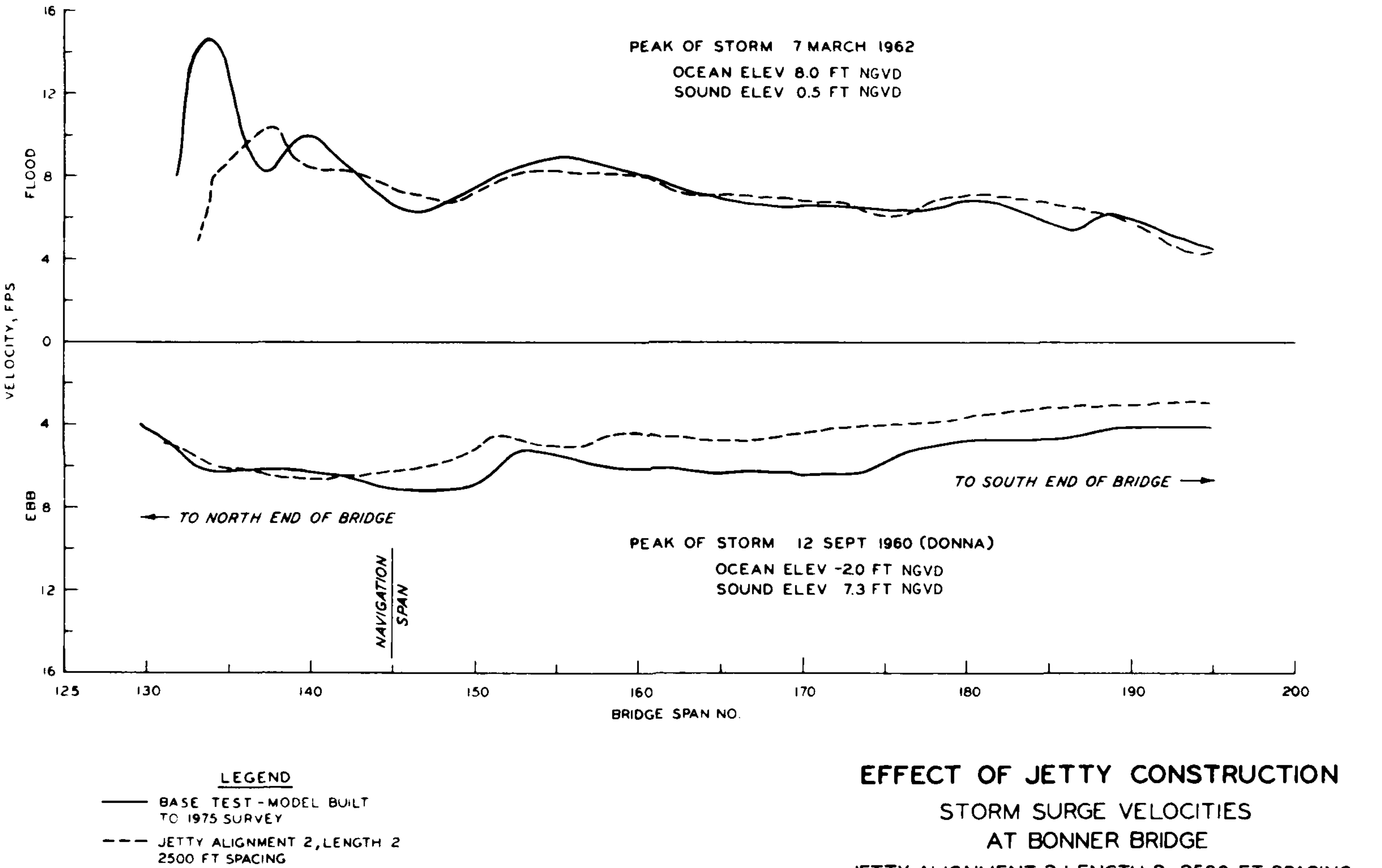
SIMULATED STORM SURGE OF 12 SEPTEMBER 1960

JETTY ALIGNMENT 2, LENGTH 2
2500-FT SPACING
EBB



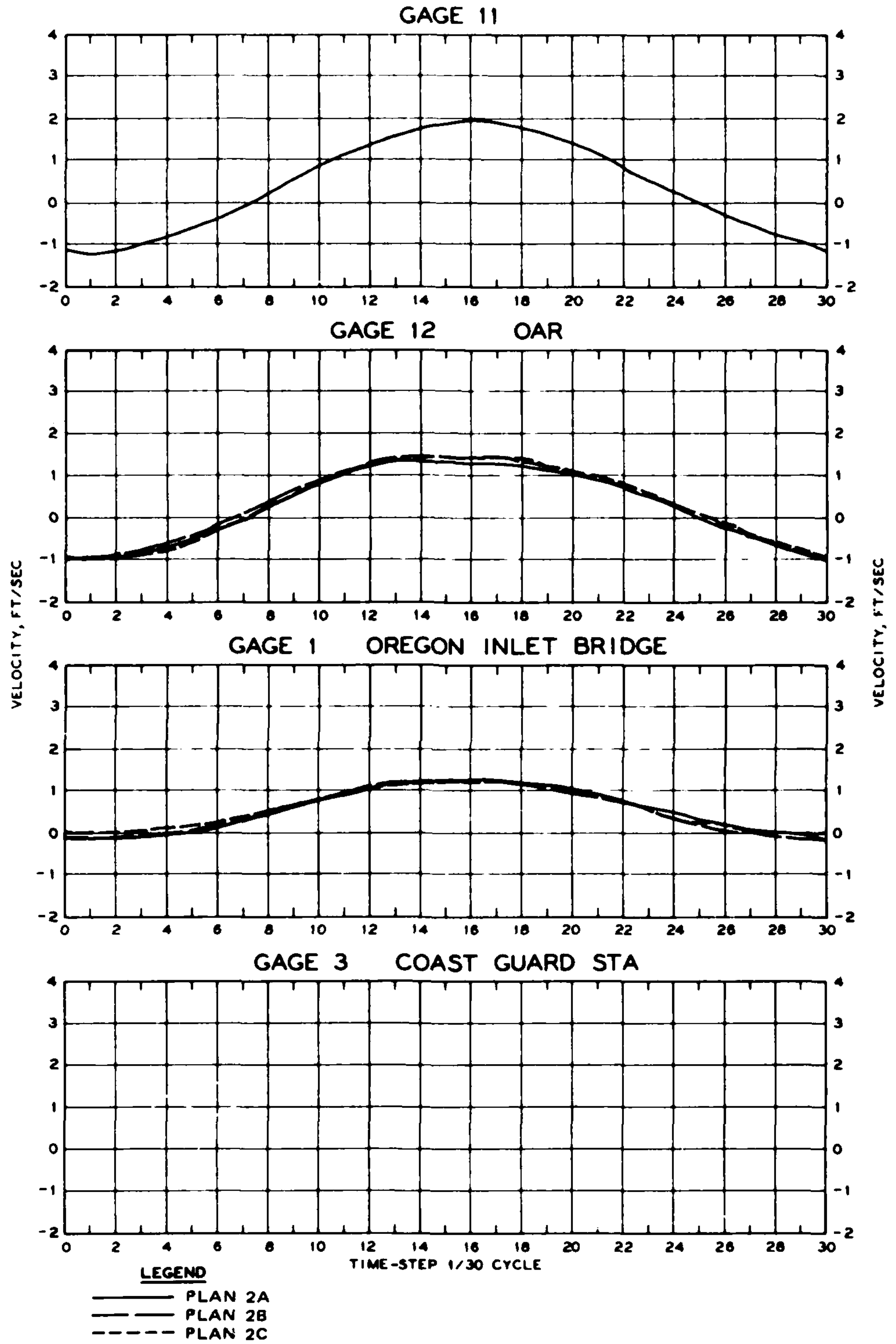
VELOCITY SCALE
10 0 10 20 30 40
FT/SEC

SURFACE CURRENT
PHOTOGRAPHS
SIMULATED STORM SURGE OF
7 MARCH 1962
JETTY ALIGNMENT 2, LENGTH 2
2500-FT SPACING
FLOOD



EFFECT OF JETTY CONSTRUCTION

STORM SURGE VELOCITIES
AT BONNER BRIDGE
JETTY ALIGNMENT 2, LENGTH 2 2500-FT SPACING



NOTE: PLAN 2A = JETTY ALIGNMENT 2, LENGTH 2, 2500-FT SPACING WITH 400- x 20-FT CHANNEL ACROSS OCEAN BAR

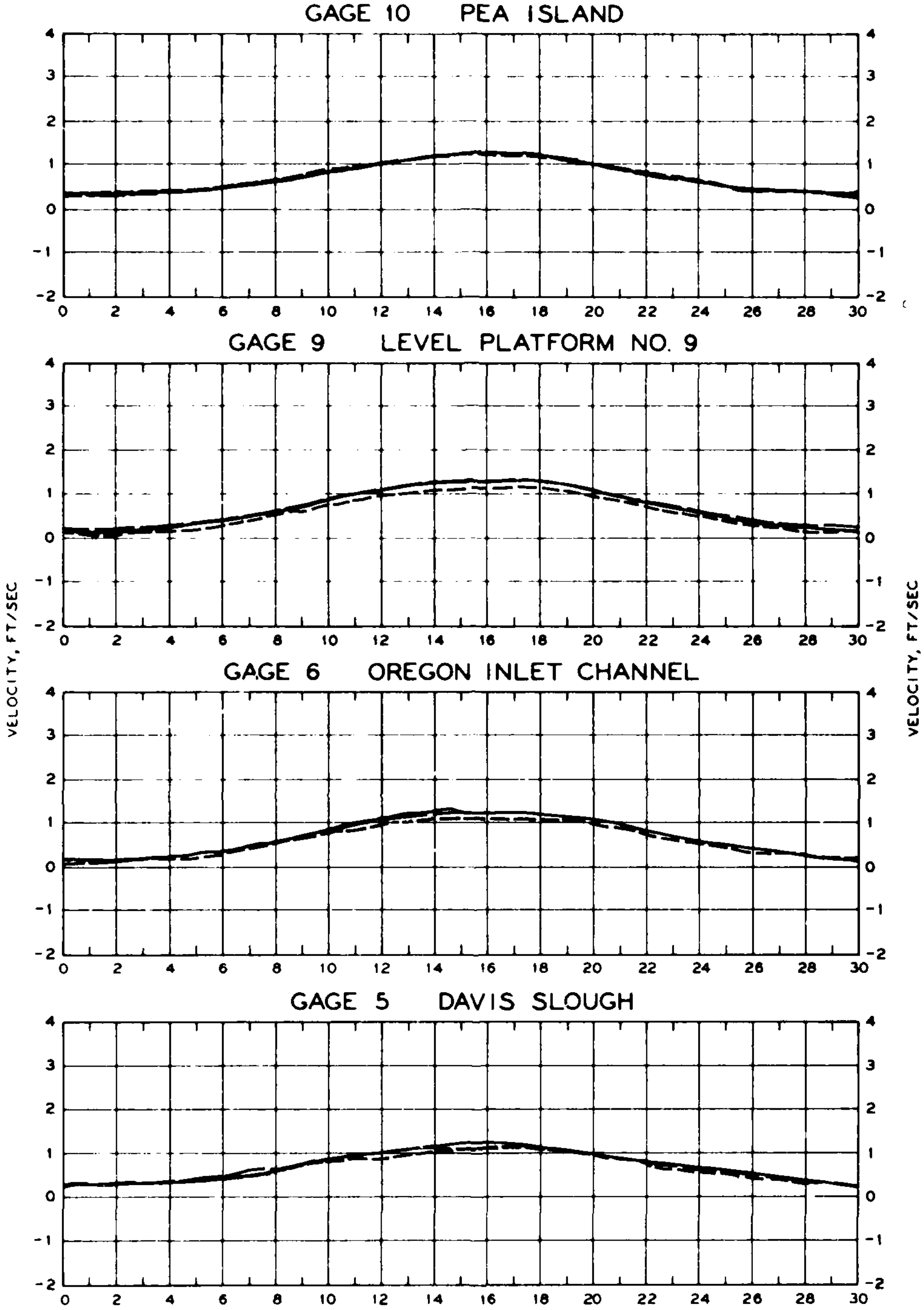
PLAN 2B = BASE I WITH 100- x 14-FT CHANNEL AT BRIDGE

PLAN 2C = BASE I WITH 100- x 14-FT CHANNEL AT BRIDGE AND 6 FT OF BOTTOM PROTECTION ALONG BRIDGE

TIDAL HEIGHTS

PLANS 2A, 2B, AND 2C

GAGES 11, 12, 1, AND 3



LEGEND

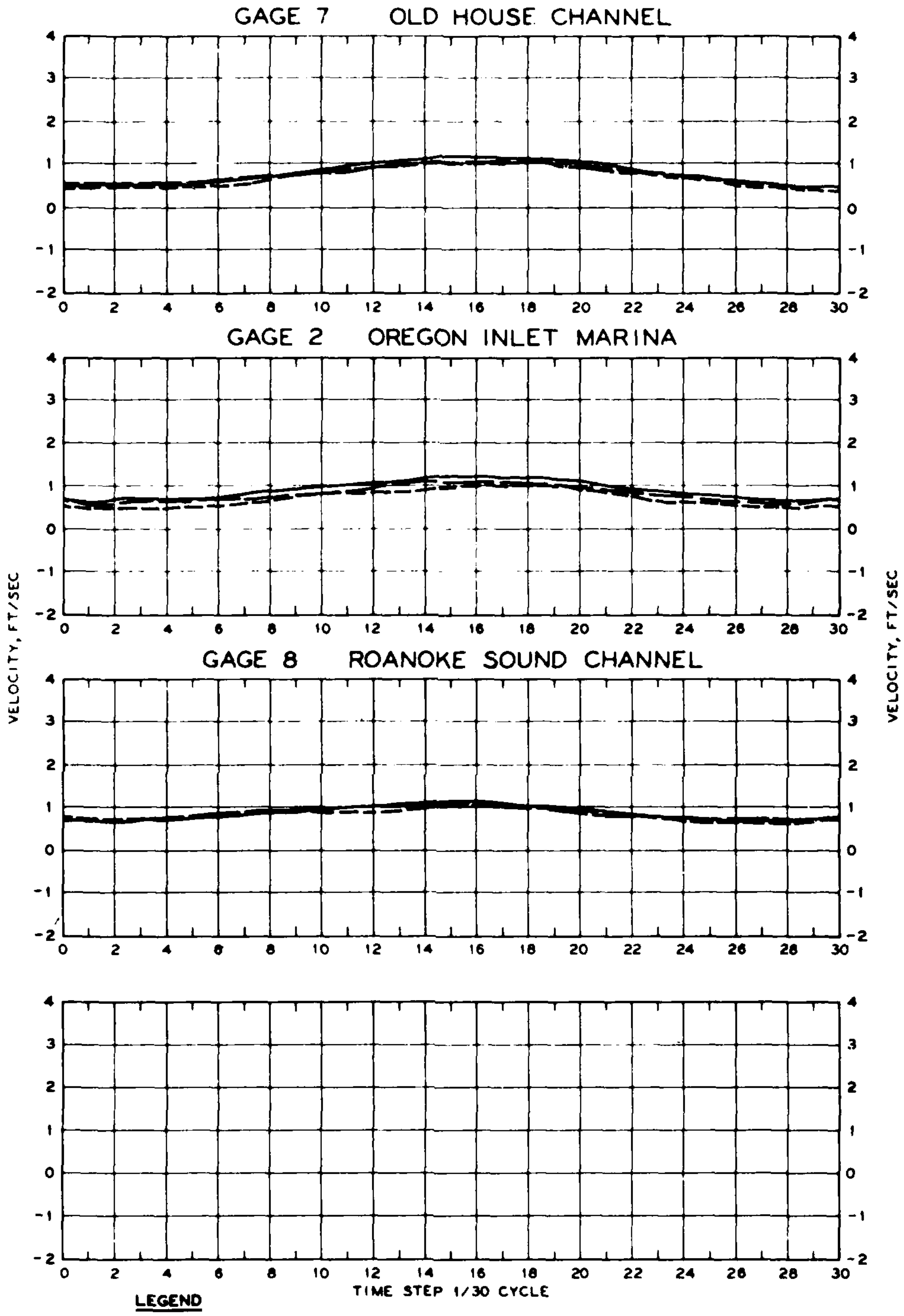
——— PLAN 2A
— — PLAN 2B
- - - - PLAN 2C

NOTE: PLAN 2A = JETTY ALIGNMENT 2, LENGTH 2, 2500-FT SPACING WITH 400- x 20-FT CHANNEL ACROSS OCEAN BAR.

PLAN 2B = BASE I WITH 100- x 14-FT CHANNEL AT BRIDGE.

PLAN 2C = BASE I WITH 100- x 14-FT CHANNEL AT BRIDGE AND 6 FT OF BOTTOM PROTECTION ALONG BRIDGE.

TIDAL HEIGHTS
PLANS 2A, 2B, AND 2C
GAGES 10, 9, 6, AND 5



NOTE: PLAN 2A = JETTY ALIGNMENT 2, LENGTH 2, 2500-FT SPACING WITH 400- x 20-FT CHANNEL ACROSS OCEAN BAR

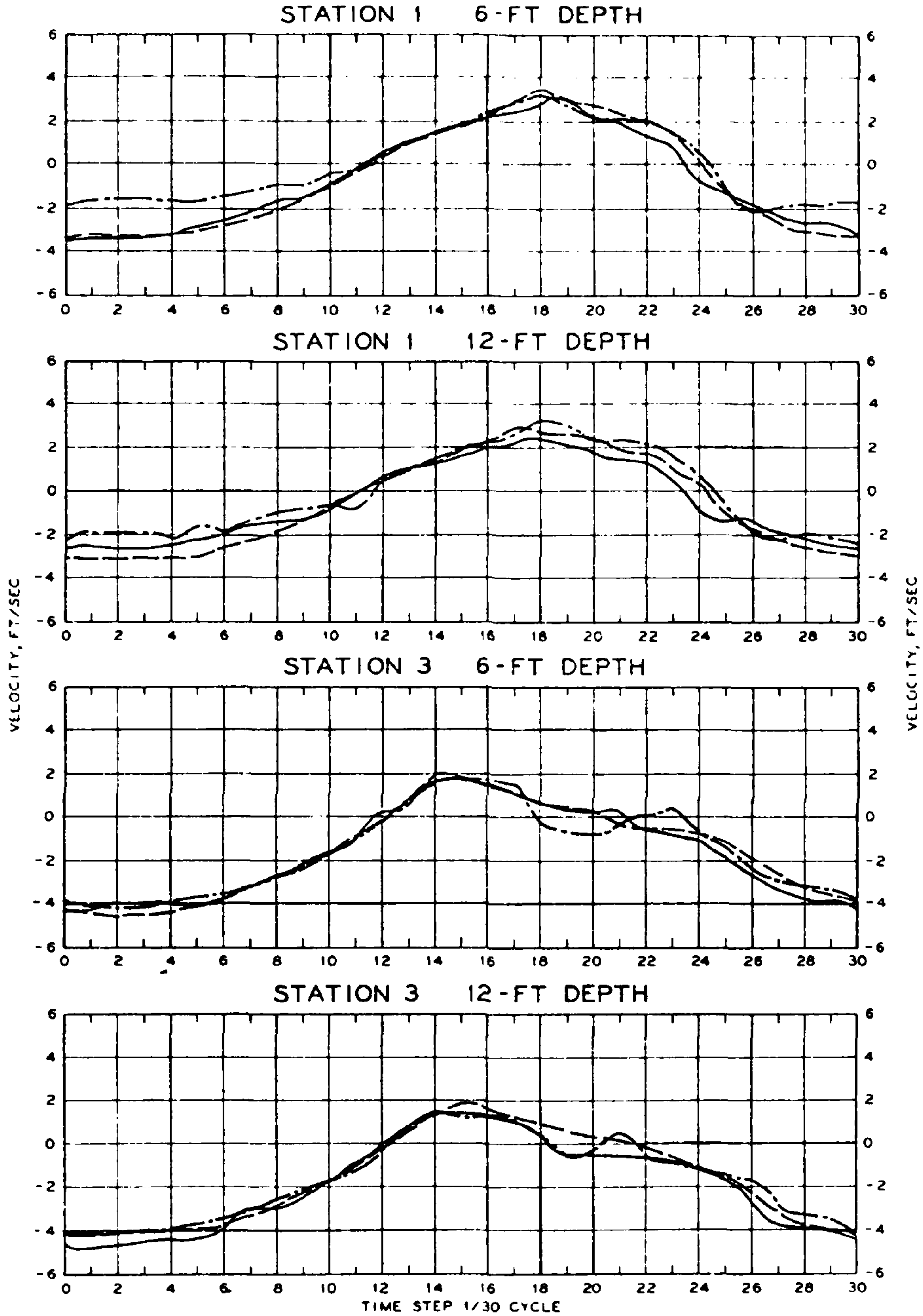
PLAN 2B = BASE I WITH 100- x 14-FT CHANNEL AT BRIDGE

PLAN 2C = BASE I WITH 100- x 14-FT CHANNEL AT BRIDGE AND 6 FT OF BOTTOM PROTECTION ALONG BRIDGE

TIDAL HEIGHTS

PLANS 2A, 2B, AND 2C

GAGES 7, 2, AND 8



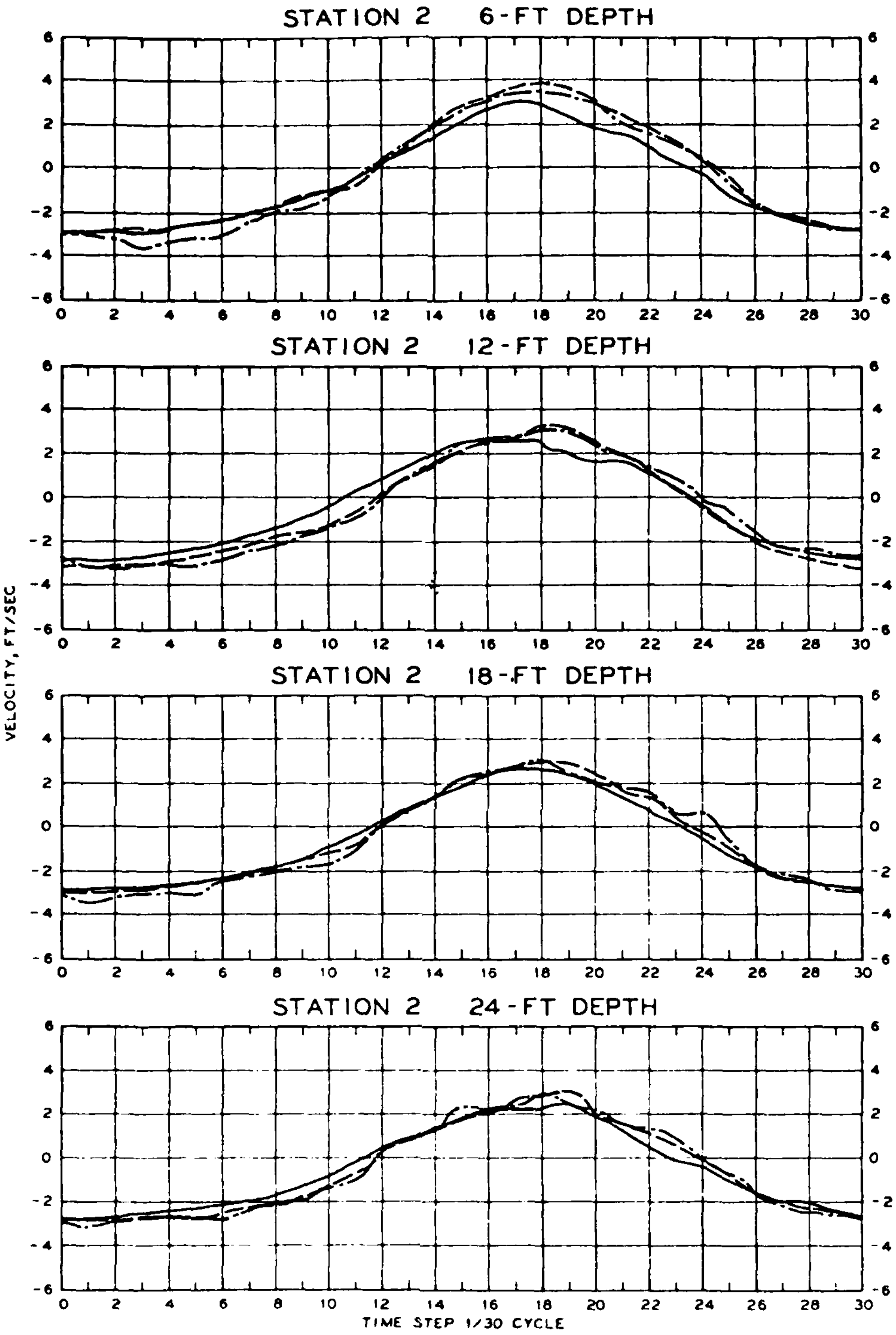
LEGEND

PLAN 2A = JETTY ALIGNMENT 2, LENGTH 2, 2500-FT SPACING

PLAN 2B = SAME AS ABOVE WITH NAVIGATION CHANNEL AT BRIDGE

PLAN 2C = SAME AS ABOVE WITH 6 FT OF BOTTOM PROTECTION ALONG BRIDGE, SPAN 129 TO SPAN 204

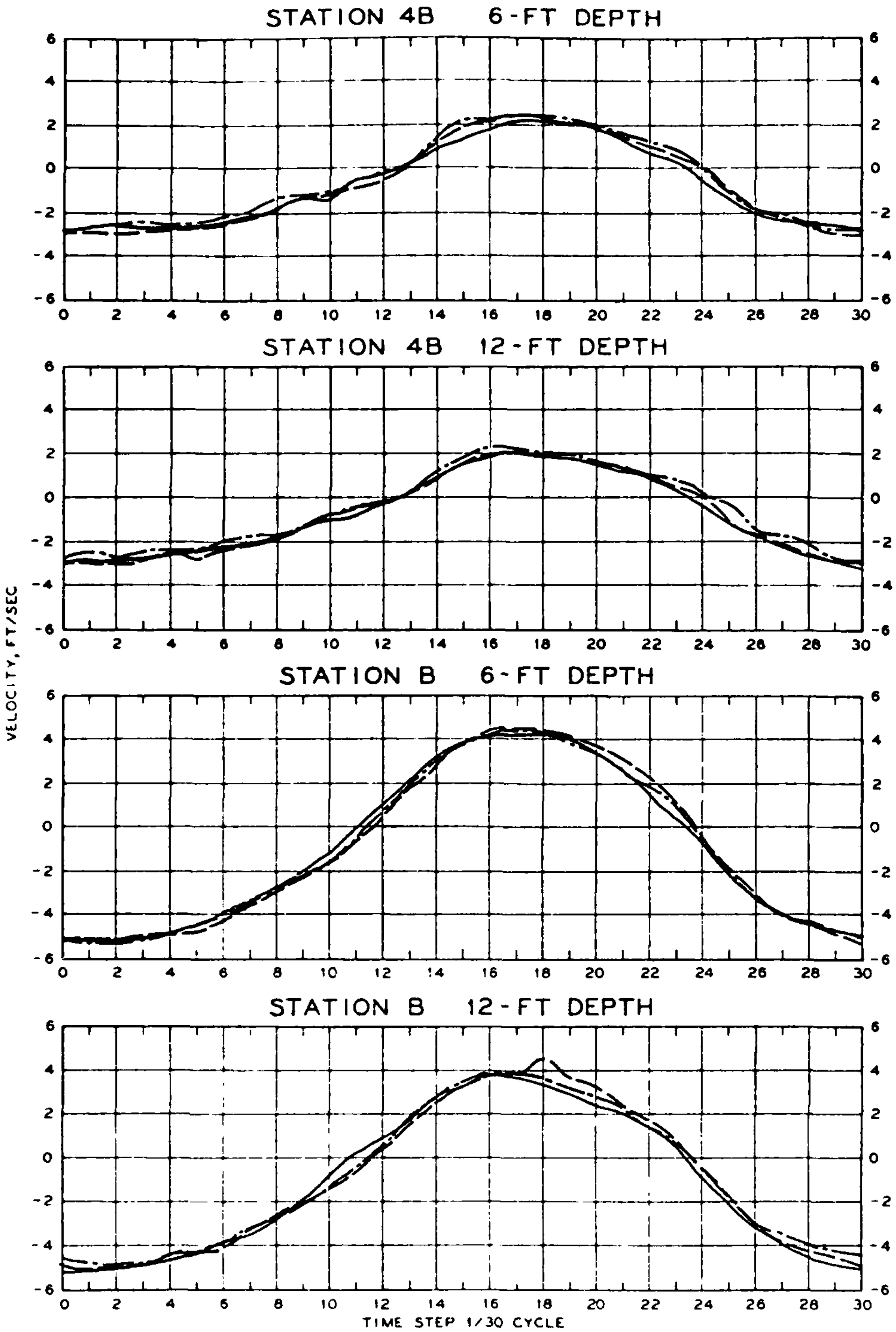
CURRENT VELOCITIES
PLANS 2A, 2B, AND 2C
STATIONS 1 AND 3



LEGEND

- PLAN 2A = JETTY ALIGNMENT 2, LENGTH 2, 2500-FT SPACING
- PLAN 2B = SAME AS ABOVE WITH NAVIGATION CHANNEL AT BRIDGE
- PLAN 2C = SAME AS ABOVE WITH 6 FT OF BOTTOM PROTECTION ALONG BRIDGE, SPAN 129 TO SPAN 204

CURRENT VELOCITIES
PLANS 2A, 2B, AND 2C
STATION 2



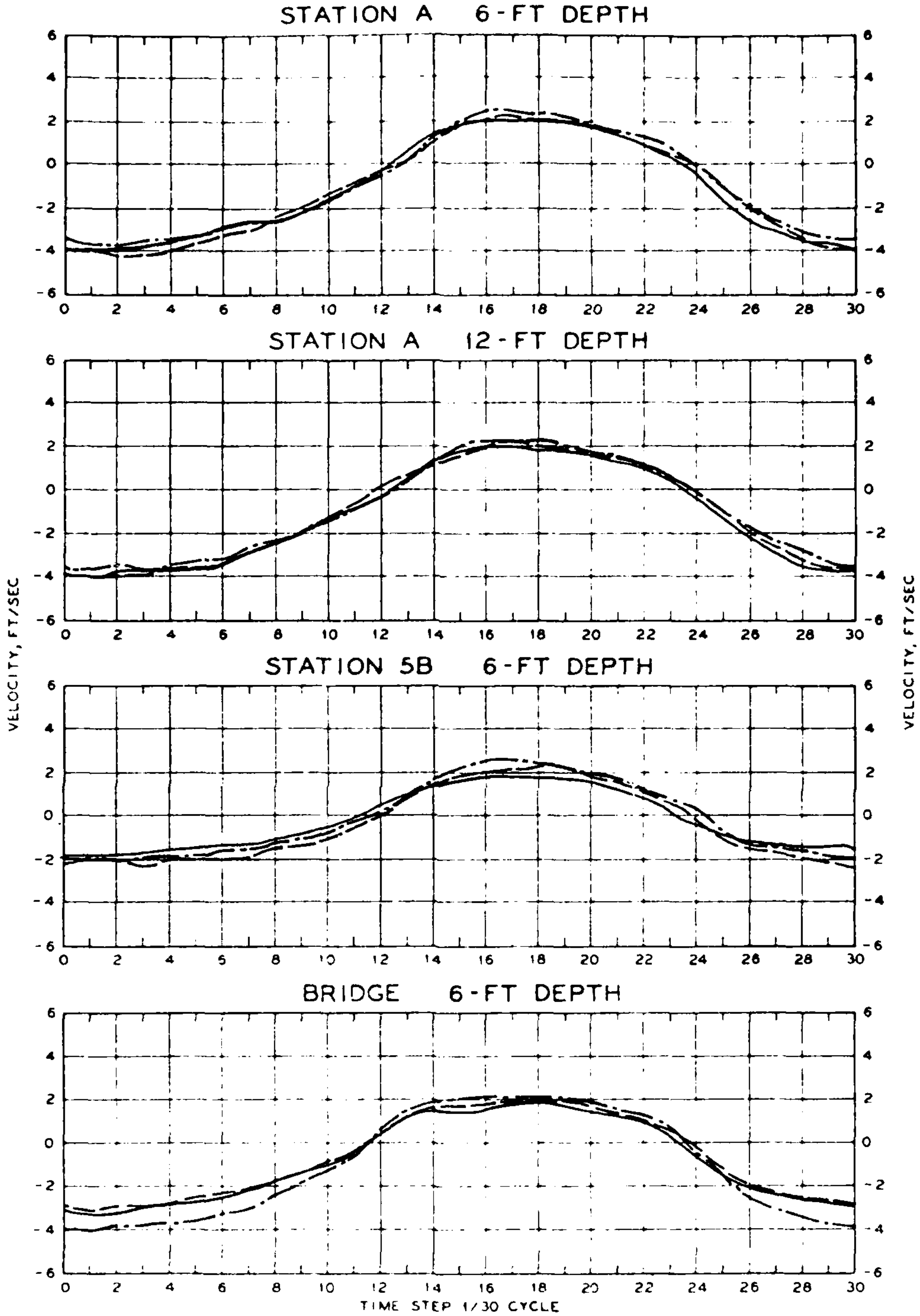
LEGEND

- PLAN 2A = JETTY ALIGNMENT 2, LENGTH 2, 2500-FT SPACING
- PLAN 2B = SAME AS ABOVE WITH NAVIGATION CHANNEL AT BRIDGE
- PLAN 2C = SAME AS ABOVE WITH 6 FT OF BOTTOM PROTECTION ALONG BRIDGE, SPAN 129 TO SPAN 204

CURRENT VELOCITIES

PLANS 2A, 2B, AND 2C

STATIONS 4B AND B



LEGEND

PLAN 2A = JETTY ALIGNMENT 2, LENGTH 2, 2500-FT SPACING

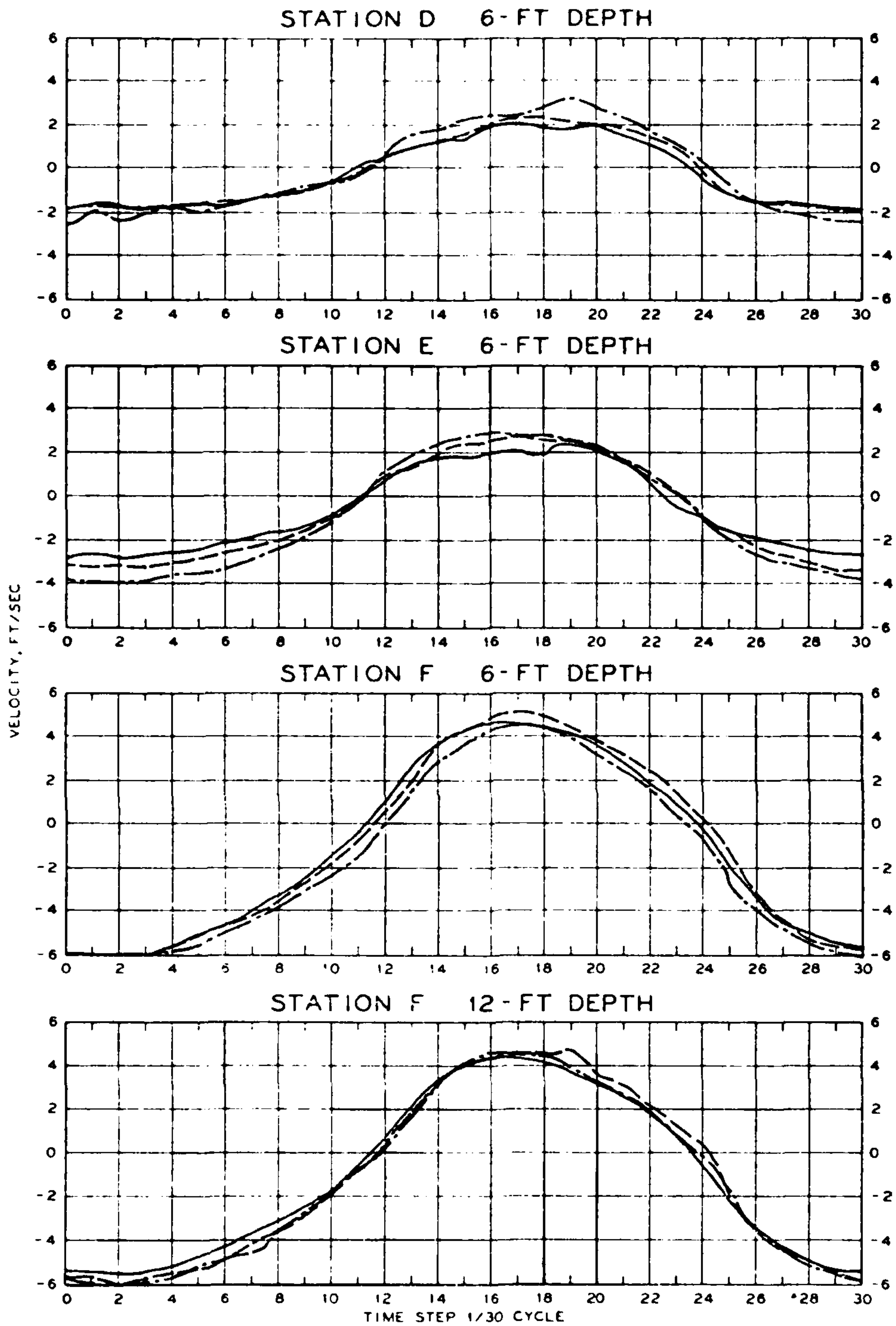
PLAN 2B = SAME AS ABOVE WITH NAVIGATION CHANNEL AT BRIDGE

PLAN 2C = SAME AS ABOVE WITH 6 FT OF BOTTOM PROTECTION ALONG BRIDGE, SPAN 129 TO SPAN 204

CURRENT VELOCITIES

PLANS 2A, 2B, AND 2C

STATIONS A, 5B, AND BRIDGE



LEGEND

- PLAN 2A = JETTY ALIGNMENT 2, LENGTH 2, 2500-FT SPACING
- PLAN 2B = SAME AS ABOVE WITH NAVIGATION CHANNEL AT BRIDGE
- PLAN 2C = SAME AS ABOVE WITH 6 FT OF BOTTOM PROTECTION ALONG BRIDGE, SPAN 129 TO SPAN 204

CURRENT VELOCITIES
PLANS 2A, 2B, AND 2C
STATIONS D, E, AND F

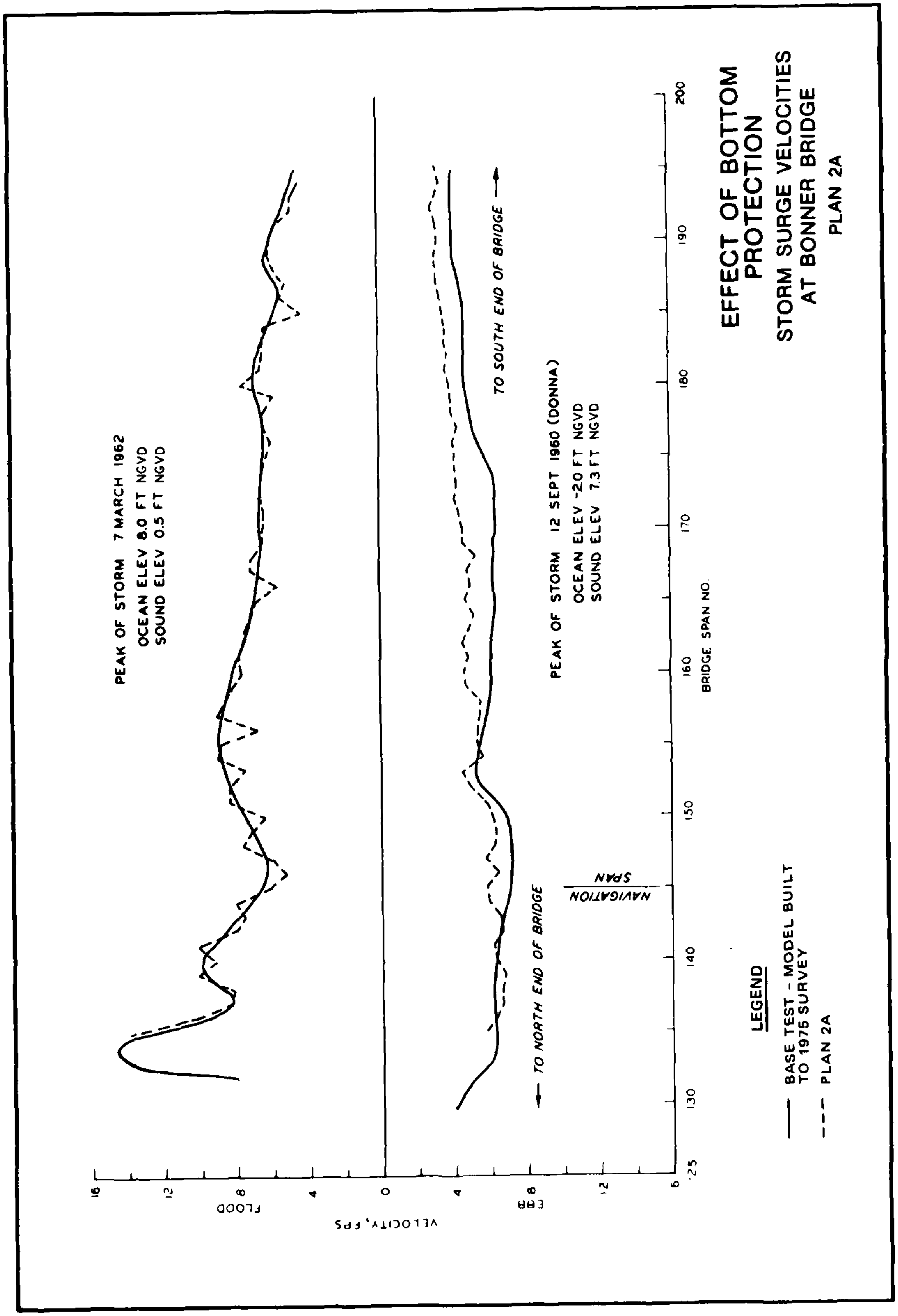
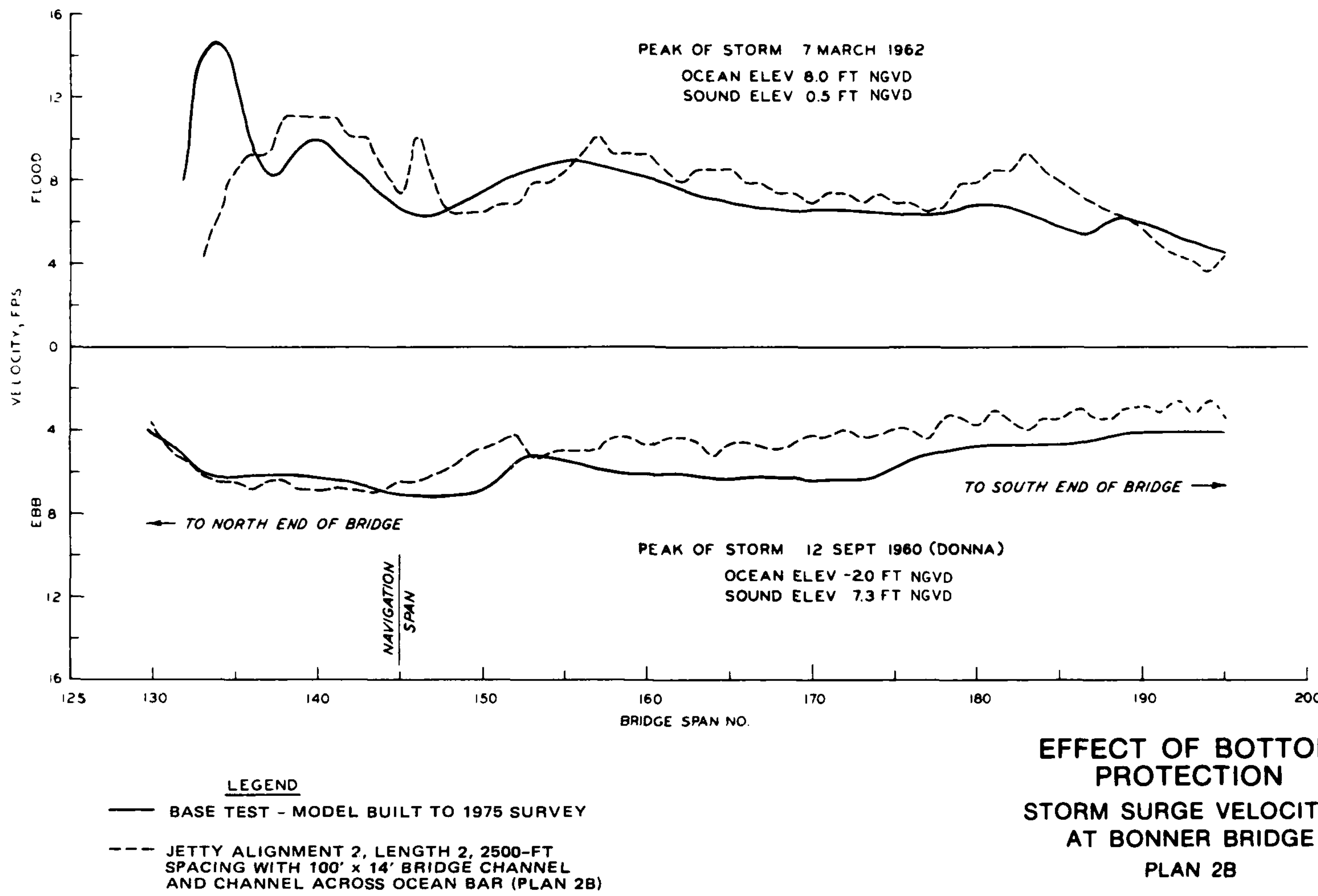

EFFECT OF BOTTOM PROTECTION
STORM SURGE VELOCITIES AT BONNER BRIDGE
PLAN 2A
PEAK OF STORM 7 MARCH 1962
OCEAN ELEV 8.0 FT NGVD
SOUND ELEV 0.5 FT NGVD
PEAK OF STORM 12 SEPT 1960 (DONNA)
OCEAN ELEV -2.0 FT NGVD
SOUND ELEV 7.3 FT NGVD
TO NORTH END OF BRIDGE
TO SOUTH END OF BRIDGE
NAVIGATION SPAN
BRIDGE SPAN NO.
VELOCITY, FPS
FLOOD
EBB
LEGEND
BASE TEST - MODEL BUILT TO 1975 SURVEY
PLAN 2A

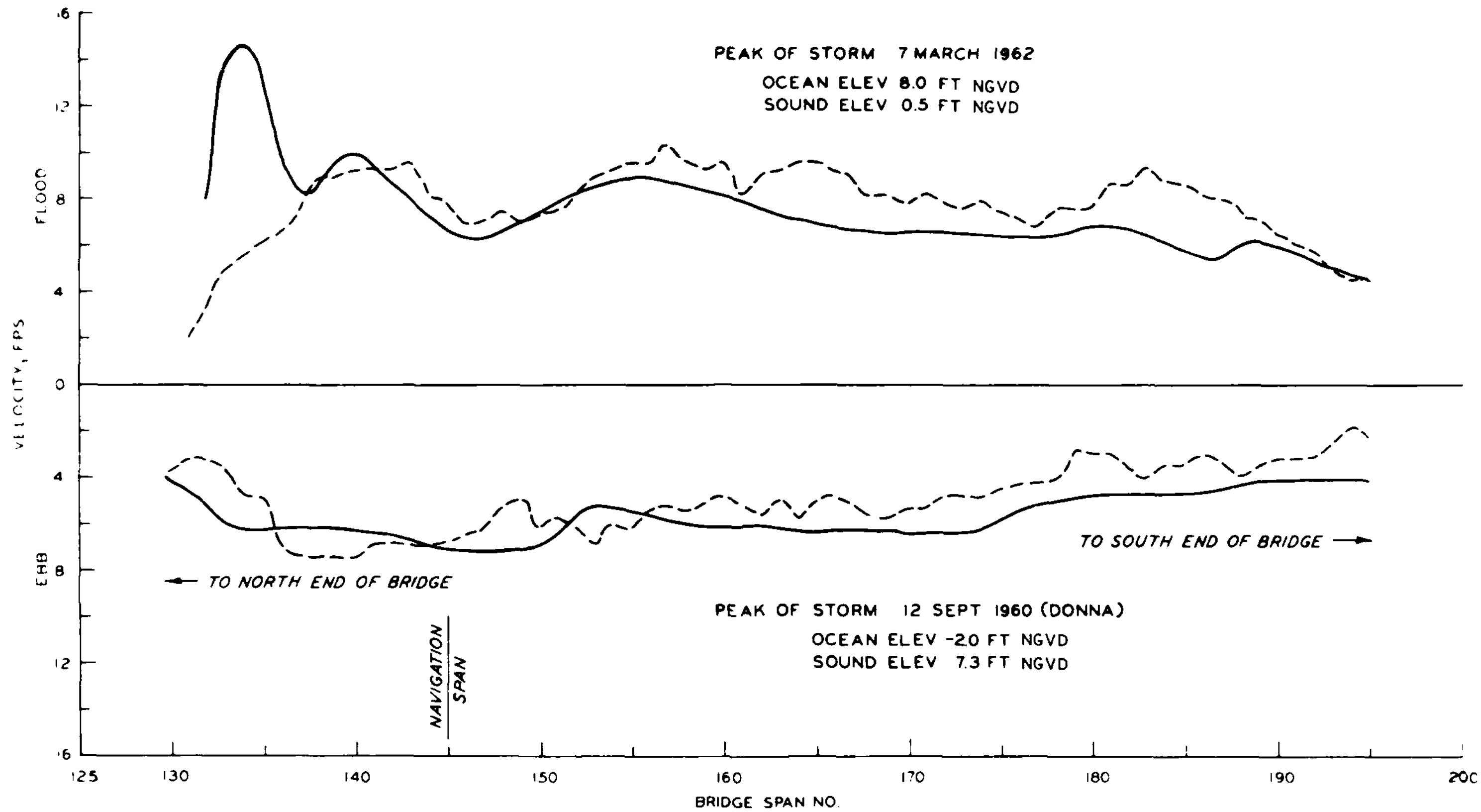
PLATE 130



EFFECT OF BOTTOM PROTECTION

STORM SURGE VELOCITIES AT BONNER BRIDGE

PLAN 2B



LEGEND

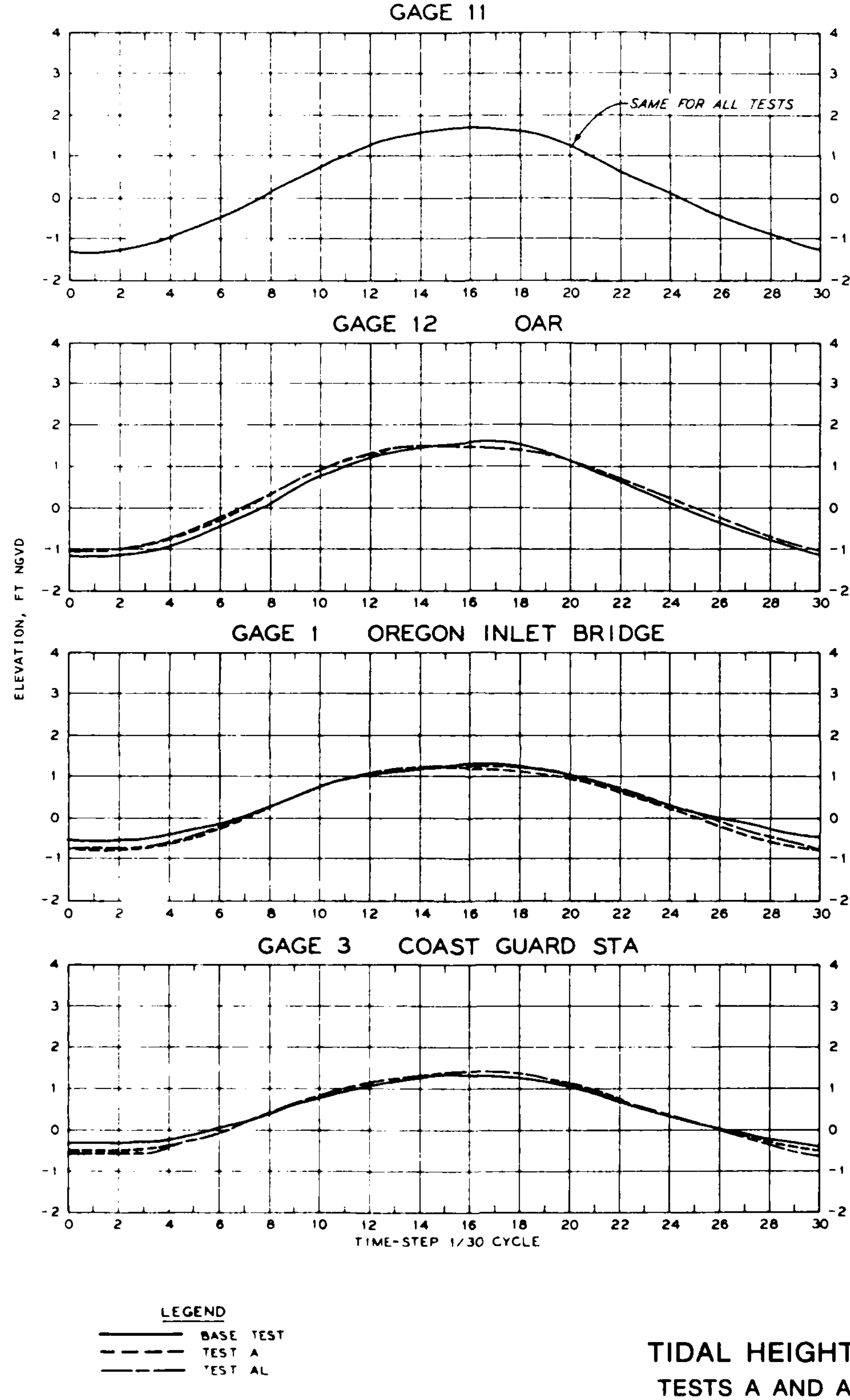
—— BASF TEST - MODEL BUILT TO 1975 SURVEY

- - - JETTY ALIGNMENT 2, LENGTH 2, 2500-FT SPACING WITH 100' x 14' BRIDGE CHANNEL, CHANNEL ACROSS OCEAN BAR, AND 6' STONES ALONG BRIDGE (PLAN 2C)

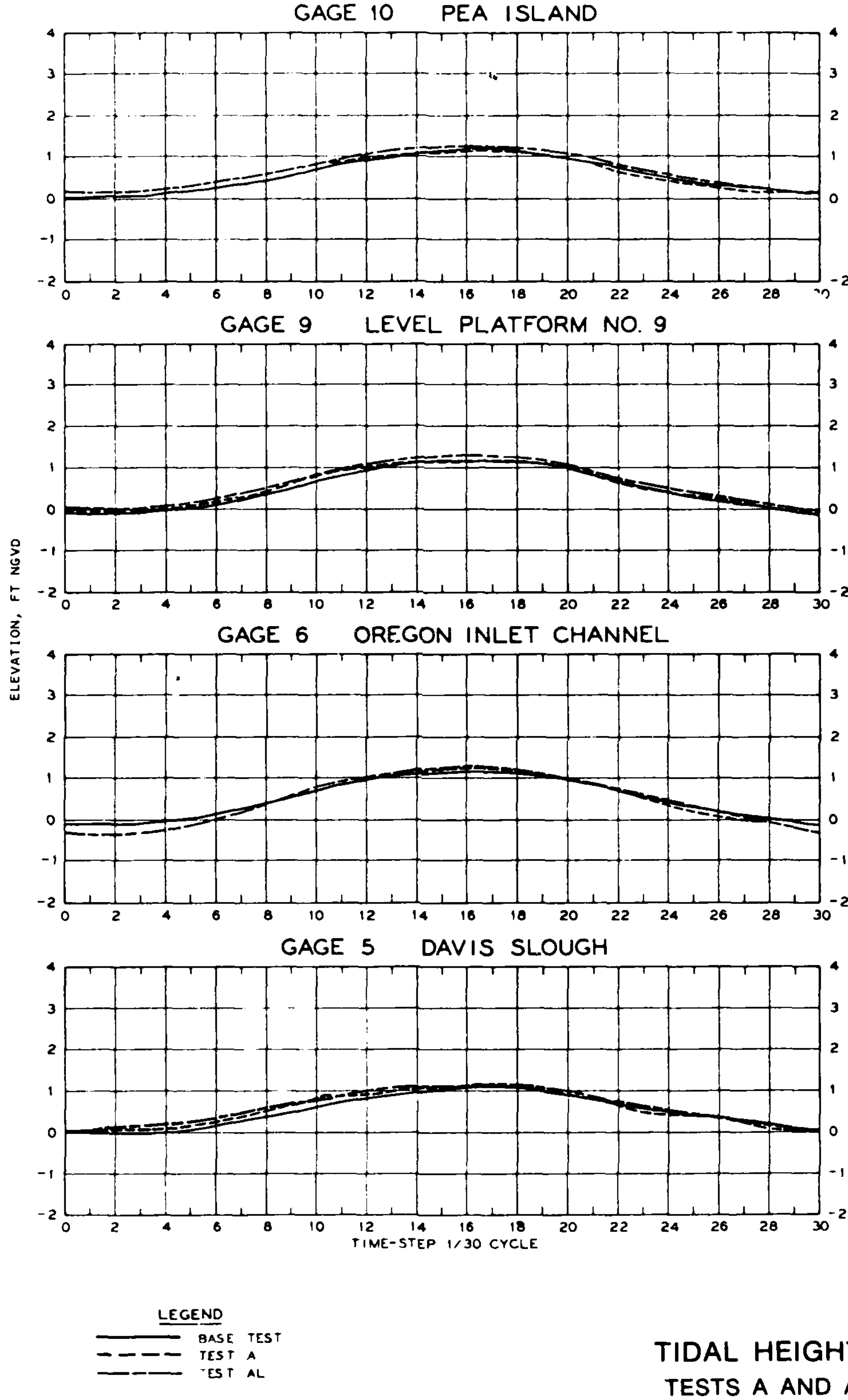
EFFECT OF BOTTOM PROTECTION

STORM SURGE VELOCITIES AT BONNER BRIDGE

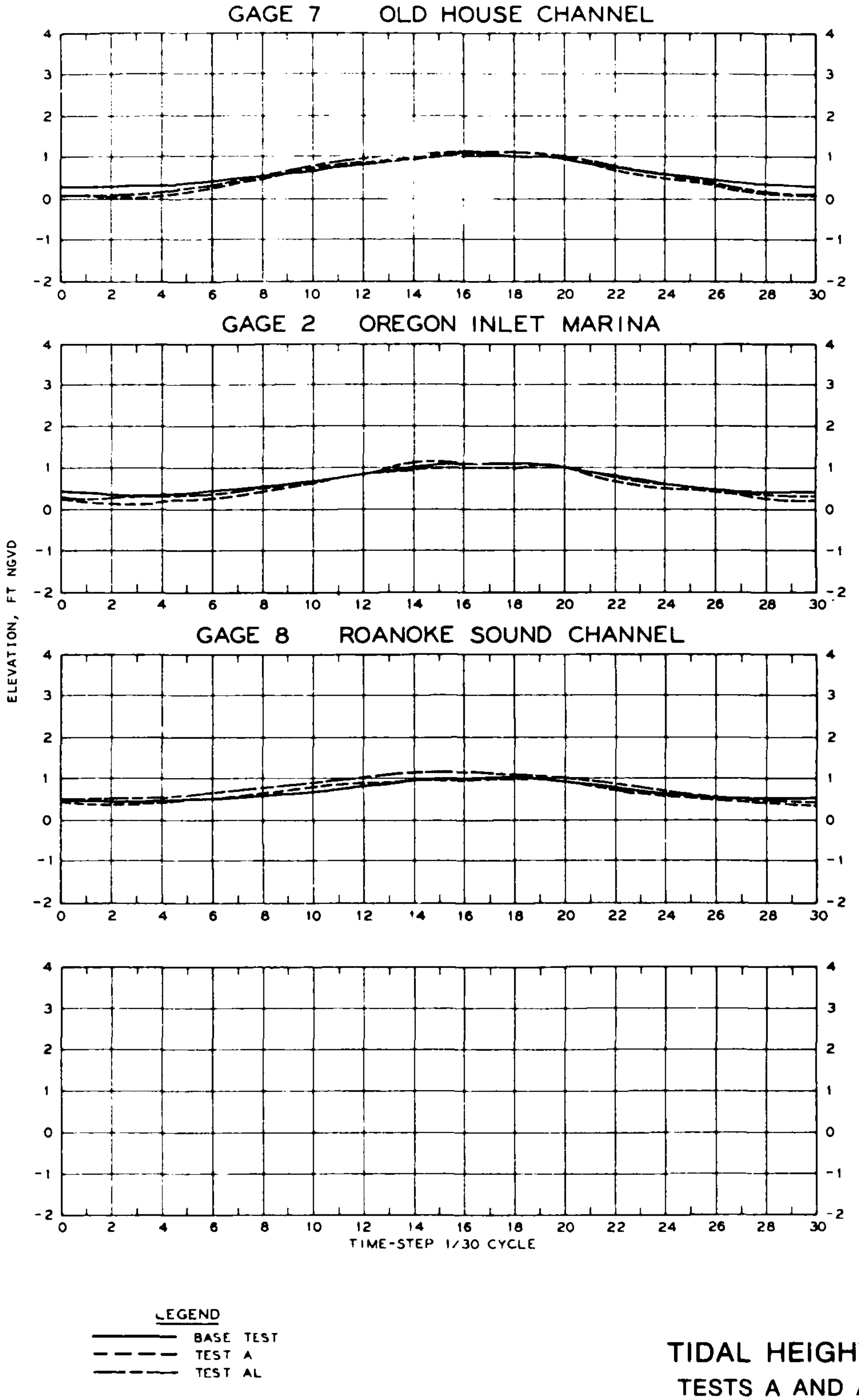
PLAN 2C



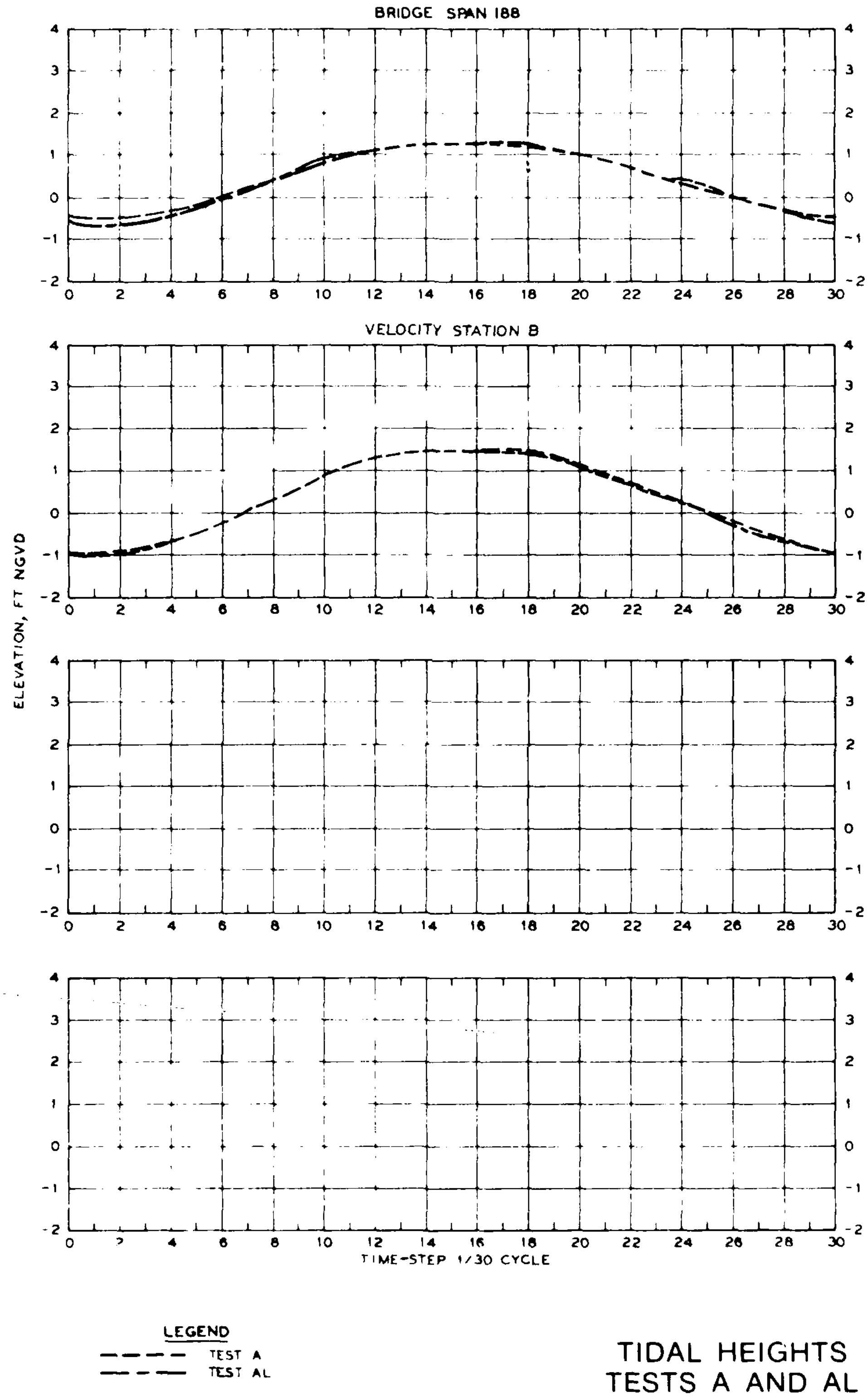
TIDAL HEIGHTS
TESTS A AND AL
GAGES 11, 12, 1, AND 3



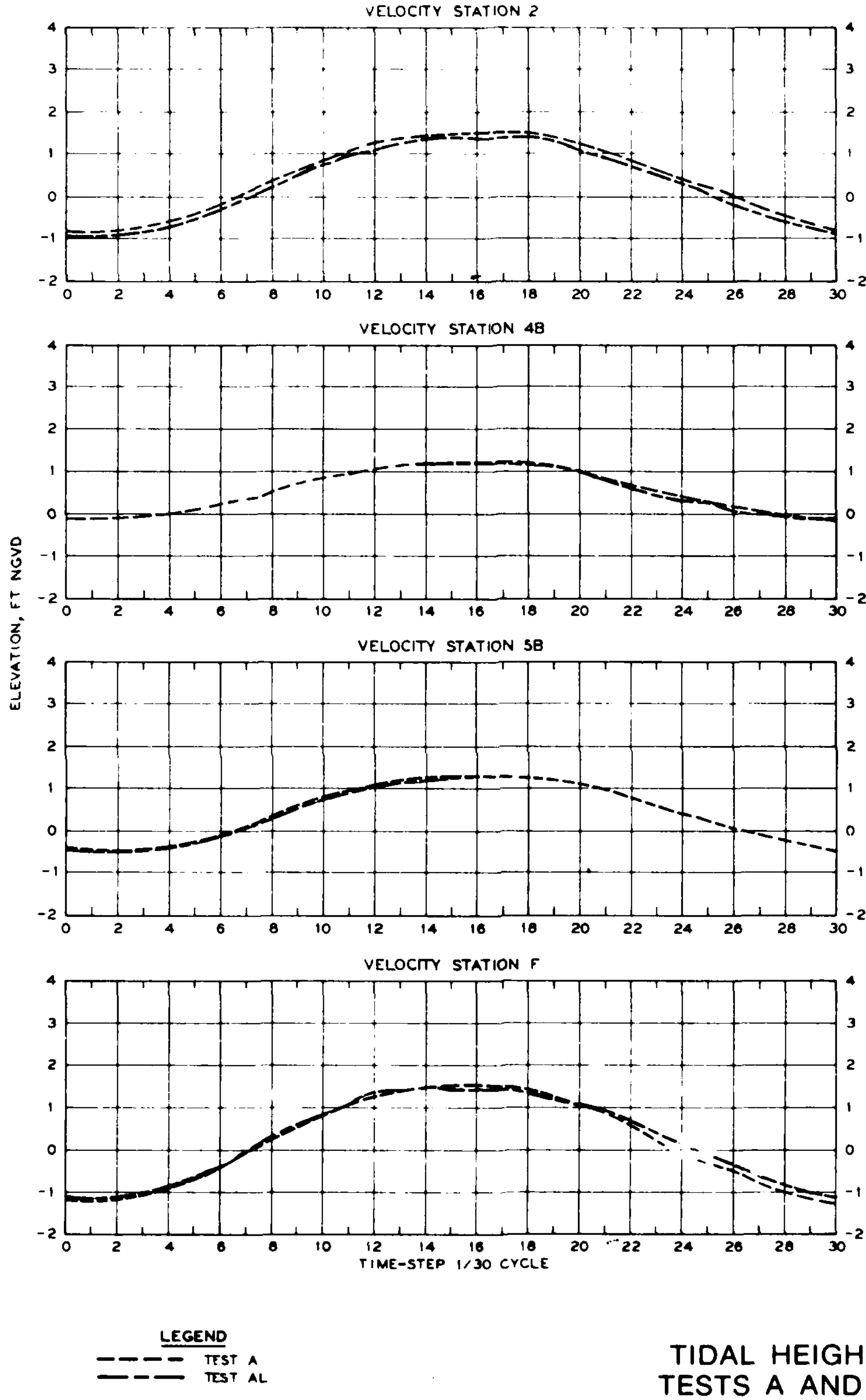
TIDAL HEIGHTS
TESTS A AND AL
GAGES 10, 9, 6, AND 5



TIDAL HEIGHTS
TESTS A AND AL
GAGES 7, 2, AND 8



TIDAL HEIGHTS
TESTS A AND AL
VELOCITY STATIONS
BRIDGE SPAN 188 AND STA B



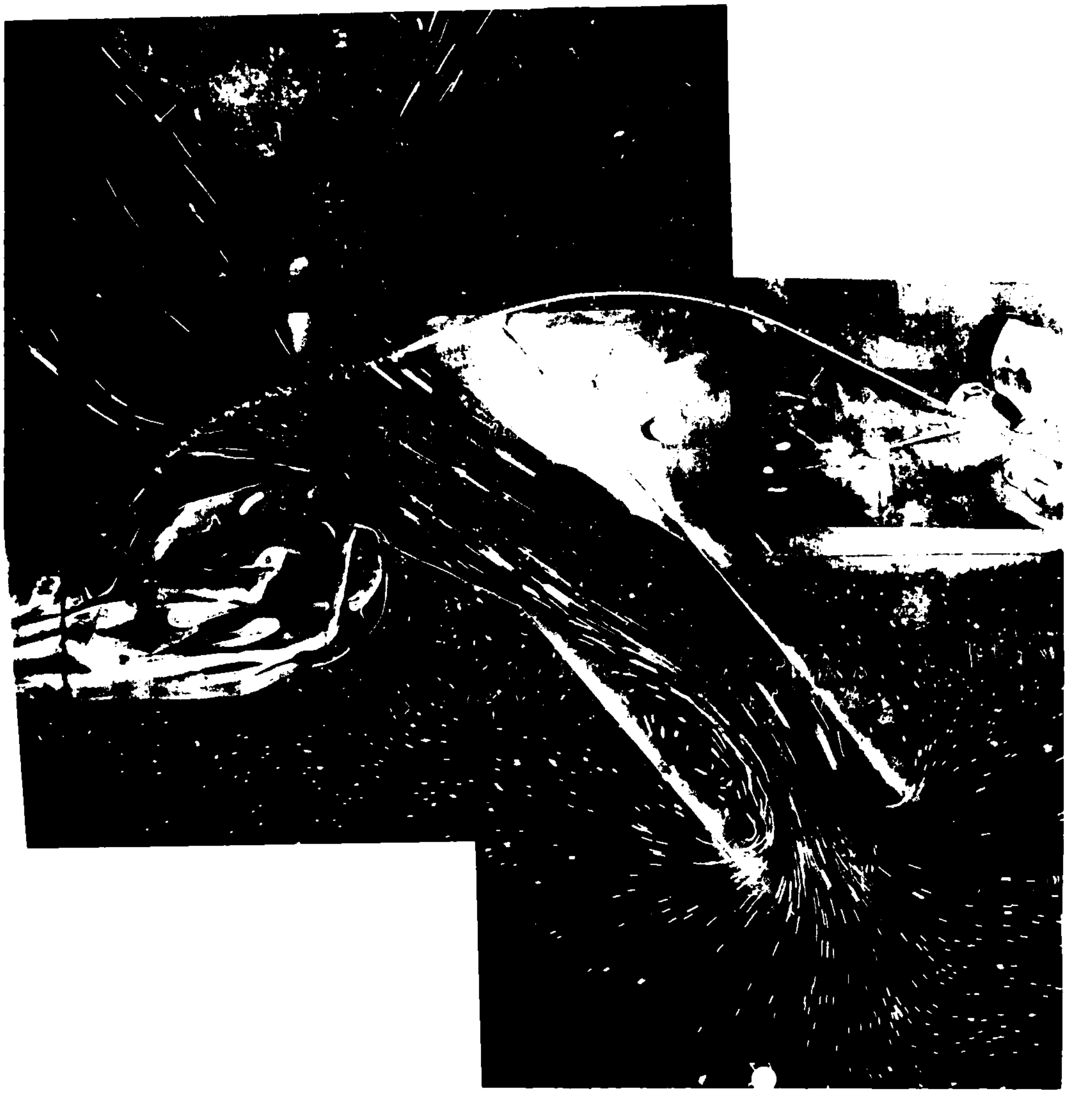
TIDAL HEIGHTS
TESTS A AND AL
VELOCITY STATIONS
2, 4B, 5B, AND F

VELOCITY SCALE

5 0 5

FT/SEC

SURFACE CURRENT PHOTOGRAPHS
TEST A
NORMAL TIDE
HOUR 1
STRENGTH OF EBB



VELOCITY SCALE
5 0 5
FT/SEC

SURFACE CURRENT
PHOTOGRAPHS
TEST A
NORMAL TIDE
HOUR 16
STRENGTH OF FLOOD

VELOCITY SCALE

5 0 5

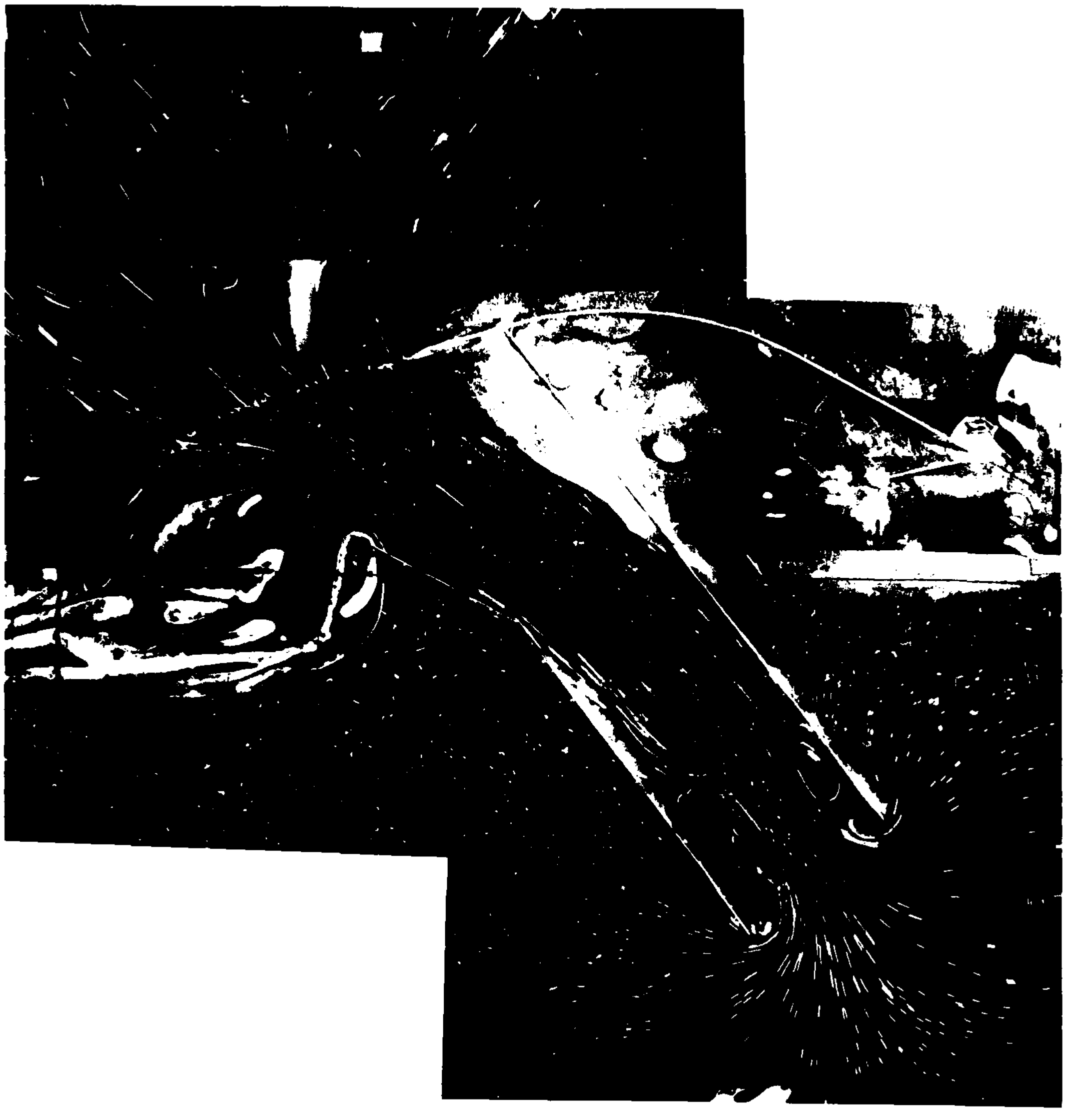
FT/SEC

SURFACE CURRENT
PHOTOGRAPHS

TEST AL
NORMAL TIDE

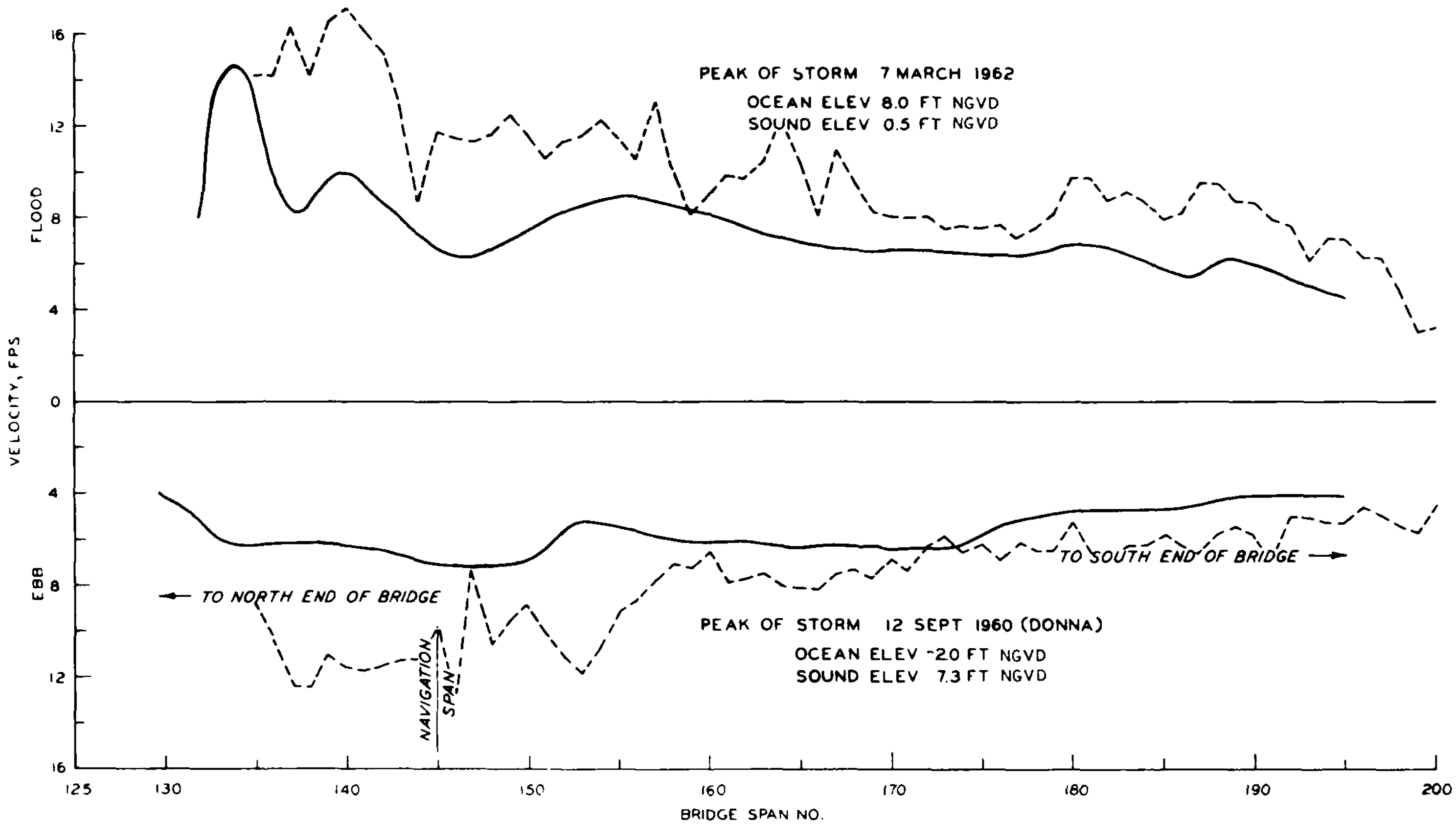
HOUR 1
STRENGTH OF EBB

PLATE 140



VELOCITY SCALE
5 0 5
FT/SEC

SURFACE CURRENT
PHOTOGRAPHS
TEST AL
NORMAL TIDE
HOUR 16
STRENGTH OF FLOOD



LEGEND

—— BASE TEST-MODEL BUILT TO 1975 SURVEY

- - - TEST A

EFFECT OF ENLARGED CHANNEL

STORM SURGE VELOCITIES
AT BONNER BRIDGE
TEST A

SURFACE CURRENT
PHOTOGRAPHS
TEST A

STORM SURGE OF
12 SEPT 1960

VELOCITY SCALE
10 0 10
FT/SEC

VELOCITY SCALE

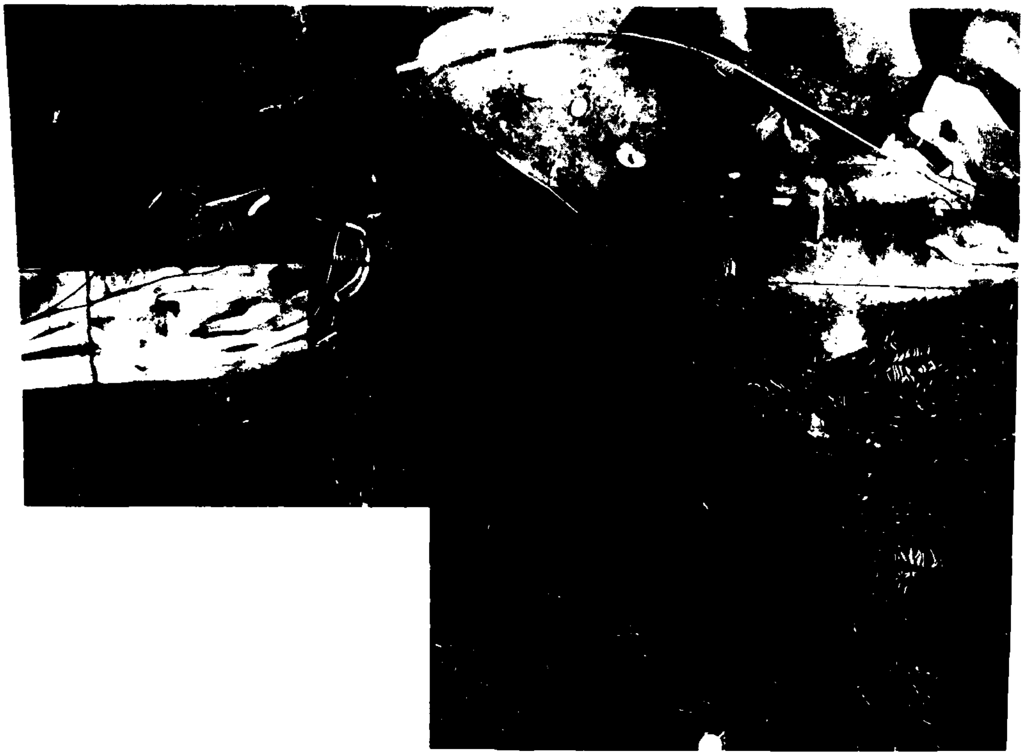
10 0 10

FT/SEC

SURFACE CURRENT PHOTOGRAPHS

TEST A

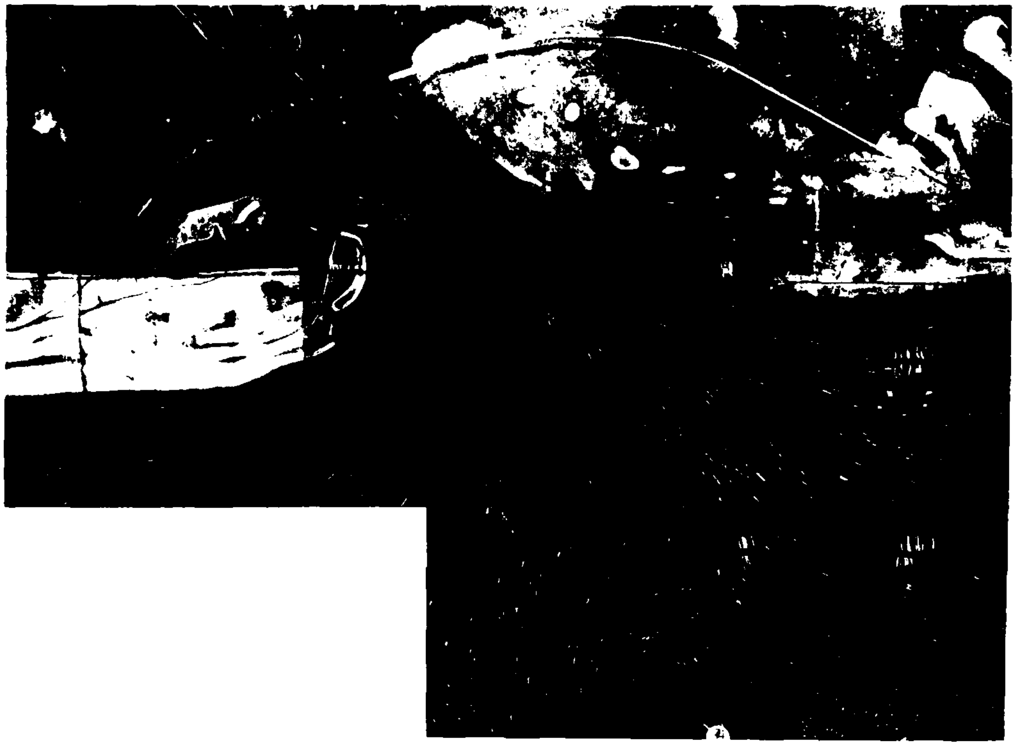
STORM SURGE OF 7 MARCH 1962



SURFACE CURRENT
PHOTOGRAPHS

BOTTOM PROTECTION TEST
TEST 2

TIME-STEP 1
STRENGTH OF EBB



VELOCITY SCALE

5 0 5 10

FT/SEC

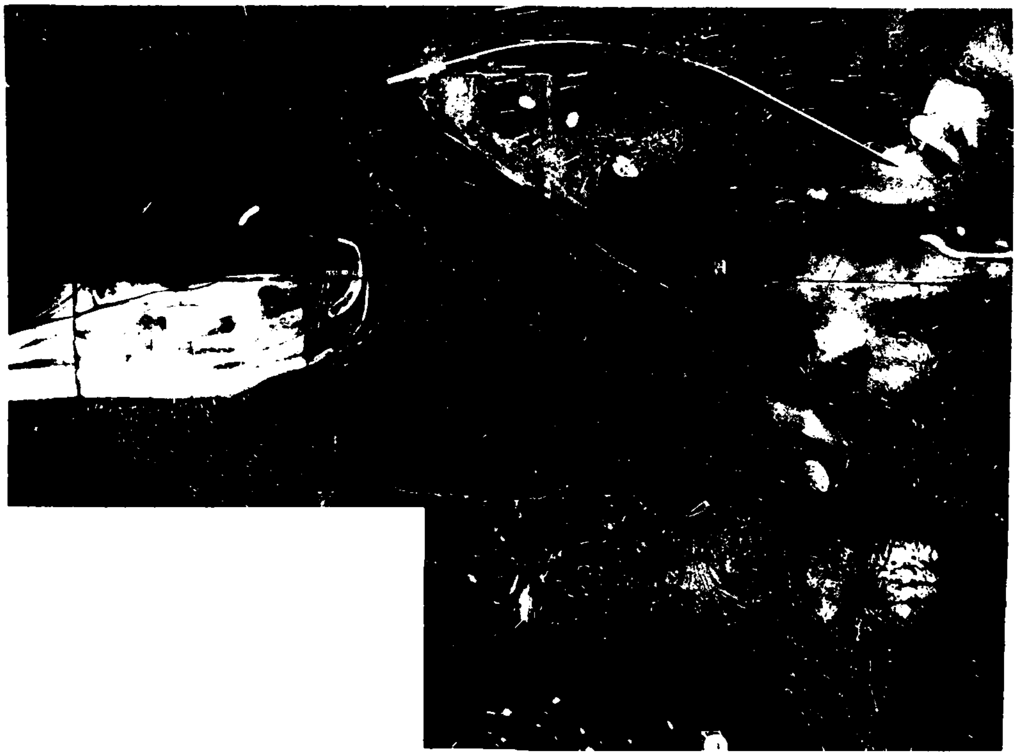
SURFACE CURRENT PHOTOGRAPHS

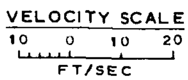
BOTTOM PROTECTION TEST

TEST 2

TIME-STEP 16

STRENGTH OF FLOOD





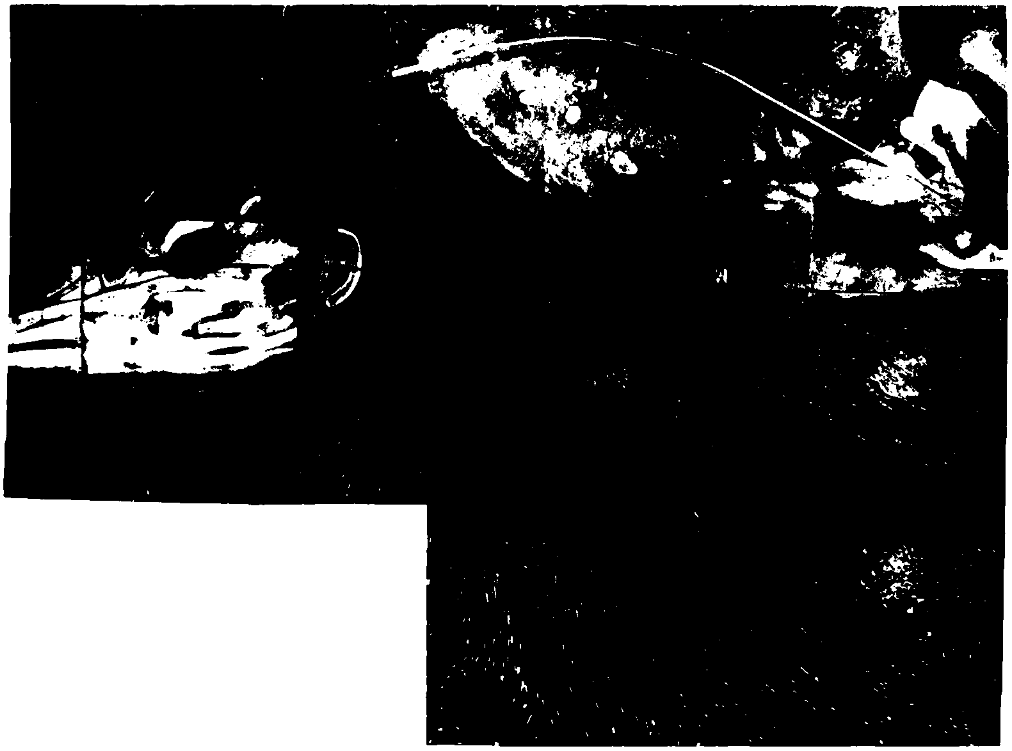
SURFACE CURRENT PHOTOGRAPHS

BOTTOM PROTECTION TEST

TEST 2

STORM SURGE OF

12 SEPTEMBER 1960



VELOCITY SCALE
10 0 10 20
FT/SEC

SURFACE CURRENT
PHOTOGRAPHS
BOTTOM PROTECTION TEST
TEST 2
STORM SURGE OF
7 MARCH 1962

VELOCITY SCALE

5 0 5 10

FT/SEC

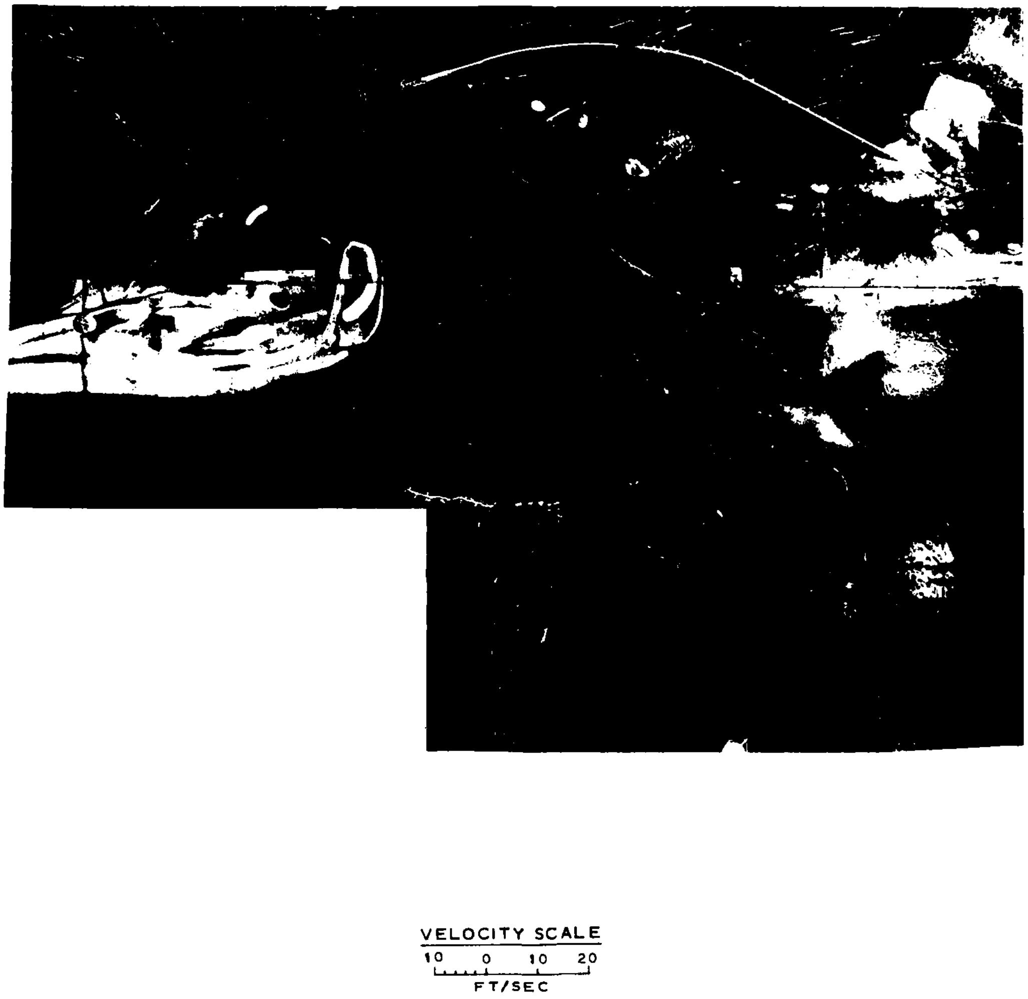
SURFACE CURRENT
PHOTOGRAPHS

BOTTOM PROTECTION TEST
TEST 7

TIME-STEP 1
STRENGTH OF EBB

VELOCITY SCALE
5 0 5 10
FT/SEC

SURFACE CURRENT
PHOTOGRAPHS
BOTTOM PROTECTION TEST
TEST 7
TIME-STEP 16
STRENGTH OF FLOOD



SURFACE CURRENT
PHOTOGRAPHS
BOTTOM PROTECTION TEST
TEST 7
STORM SURGE OF
12 SEPTEMBER 1960

VELOCITY SCALE

10 0 10 20

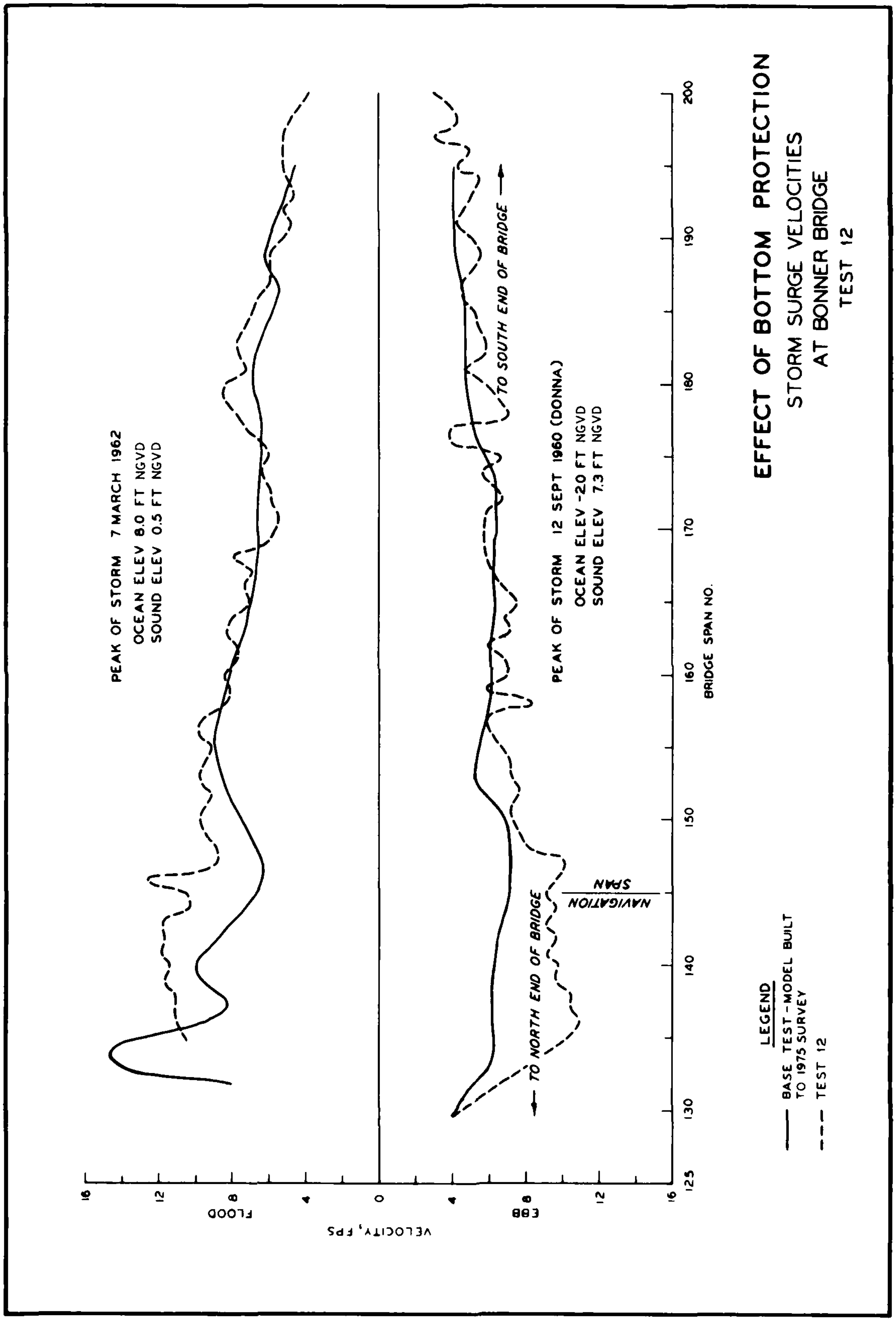
FT/SEC

SURFACE CURRENT PHOTOGRAPHS

BOTTOM PROTECTION TEST

TEST 7

STORM SURGE OF 7 MARCH 1962



EFFECT OF BOTTOM PROTECTION
STORM SURGE VELOCITIES
AT BONNER BRIDGE
TEST 12

SURFACE CURRENT PHOTOGRAPHS

BOTTOM PROTECTION TEST
TEST 13

TIME-STEP 1
STRENGTH OF EBB

VELOCITY SCALE

5 0 5 10

FT/SEC

SURFACE CURRENT PHOTOGRAPHS

BOTTOM PROTECTION TEST

TEST 13

TIME-STEP 16

STRENGTH OF FLOOD

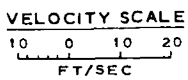
TIME-STEP 1
STRENGTH OF EBB

TIME-STEP 16
STRENGTH OF FLOOD

VELOCITY SCALE
5 0 5
FT/SEC

SURFACE CURRENT PHOTOGRAPHS
BOTTOM PROTECTION TEST
TEST 13
NORMAL TIDE

SURFACE CURRENT
PHOTOGRAPHS
BOTTOM PROTECTION TEST
TEST 13
STORM SURGE OF
12 SEPTEMBER 1960



SURFACE CURRENT
PHOTOGRAPHS
BOTTOM PROTECTION TEST
TEST 13
STORM SURGE OF
7 MARCH 1962

12 SEPT '60

7 MAR '62

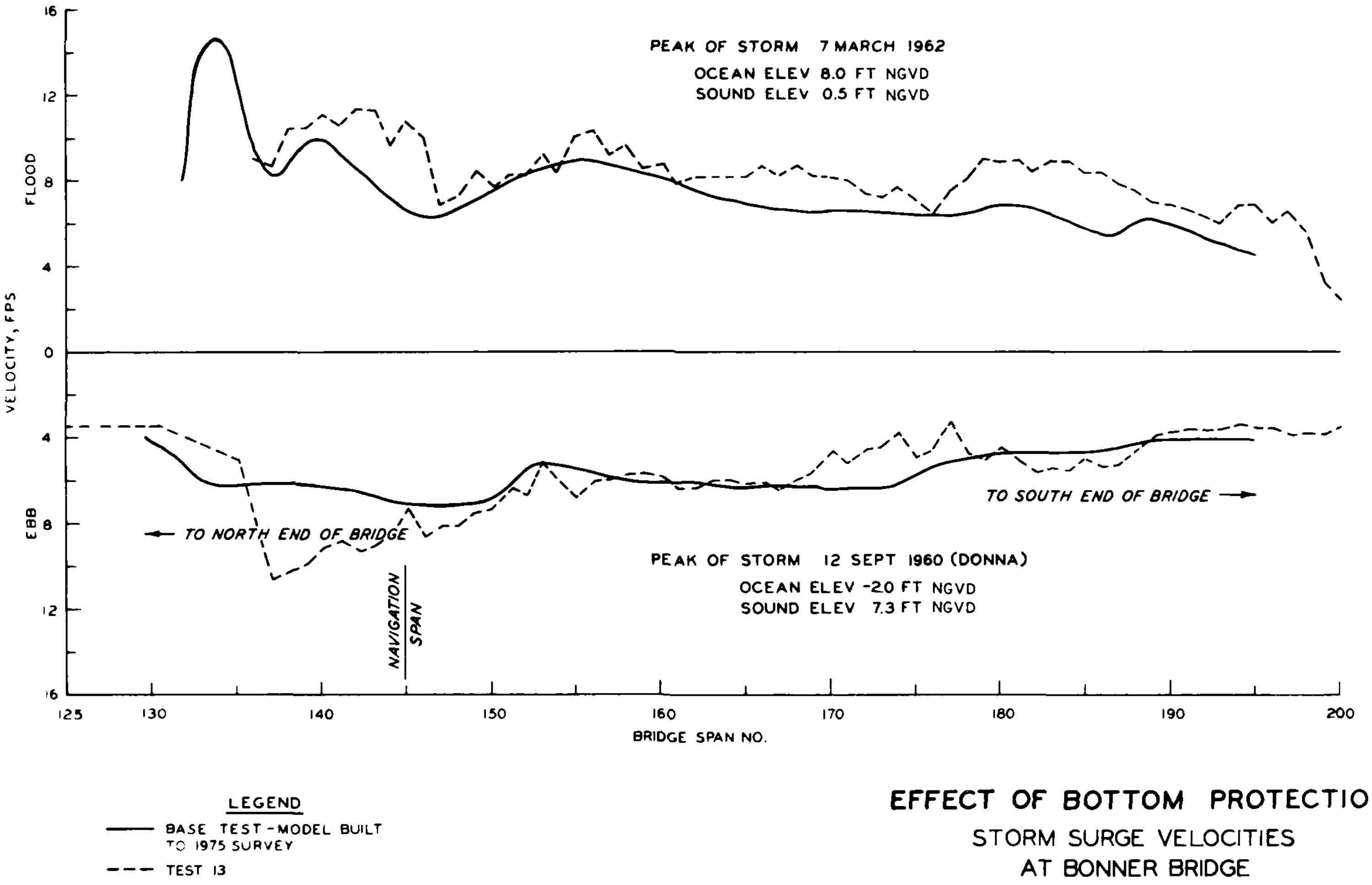
VELOCITY SCALE

10 0 10

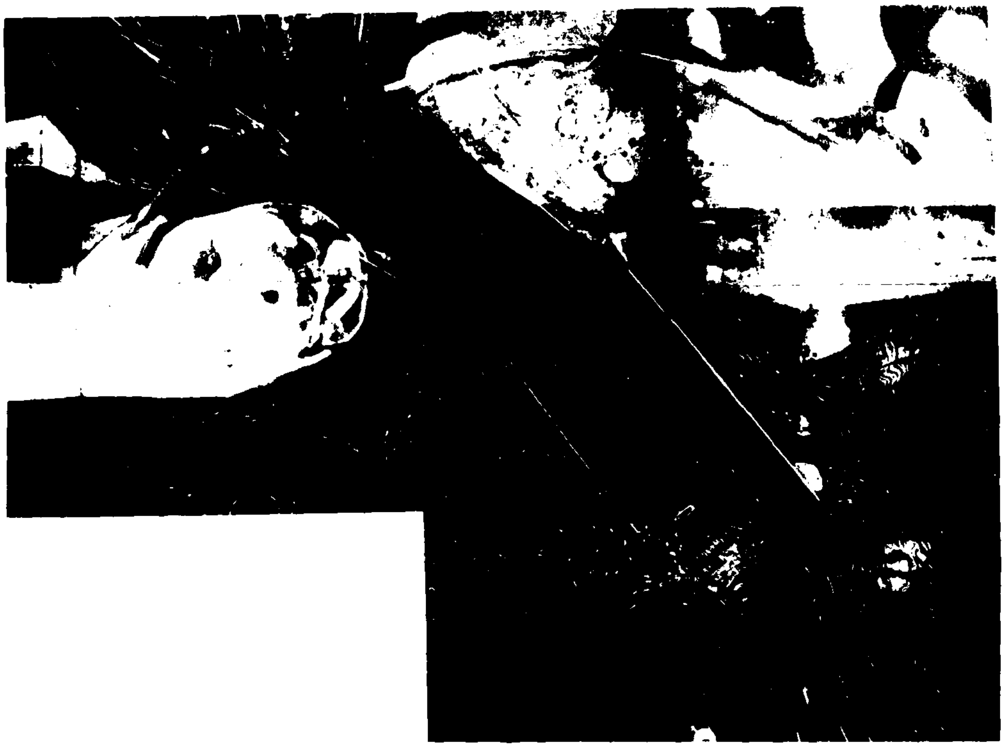
FT/SEC

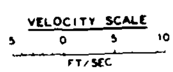
SURFACE CURRENT
PHOTOGRAPHS
BOTTOM PROTECTION TEST

TEST 13
STORM SURGES



EFFECT OF BOTTOM PROTECTION
STORM SURGE VELOCITIES
AT BONNER BRIDGE
TEST 13

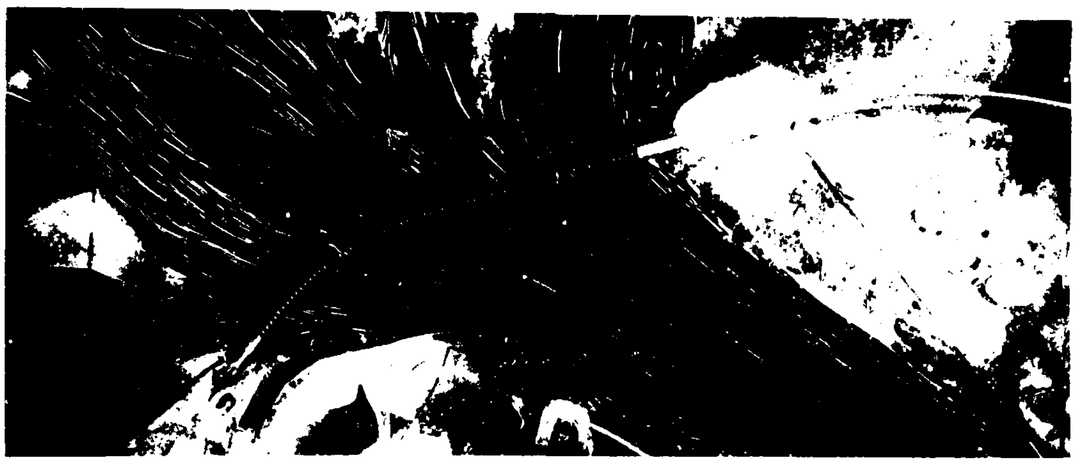




SURFACE CURRENT
PHOTOGRAPHS
BOTTOM PROTECTION TEST
TEST 18
TIME-STEP 1
STRENGTH OF EBB

SURFACE CURRENT
PHOTOGRAPHS
BOTTOM PROTECTION TEST
TEST 18
TIME-STEP 16
STRENGTH OF FLOOD

TIME-STEP 1
STRENGTH OF EBB



TIME-STEP 16
STRENGTH OF FLOOD

VELOCITY SCALE
5 0 5
FT/SEC

SURFACE CURRENT
PHOTOGRAPHS
BOTTOM PROTECTION TEST
TEST 18
NORMAL TIDE

VELOCITY SCALE

10 0 10 20

FT/SEC

SURFACE CURRENT PHOTOGRAPHS

BOTTOM PROTECTION TEST

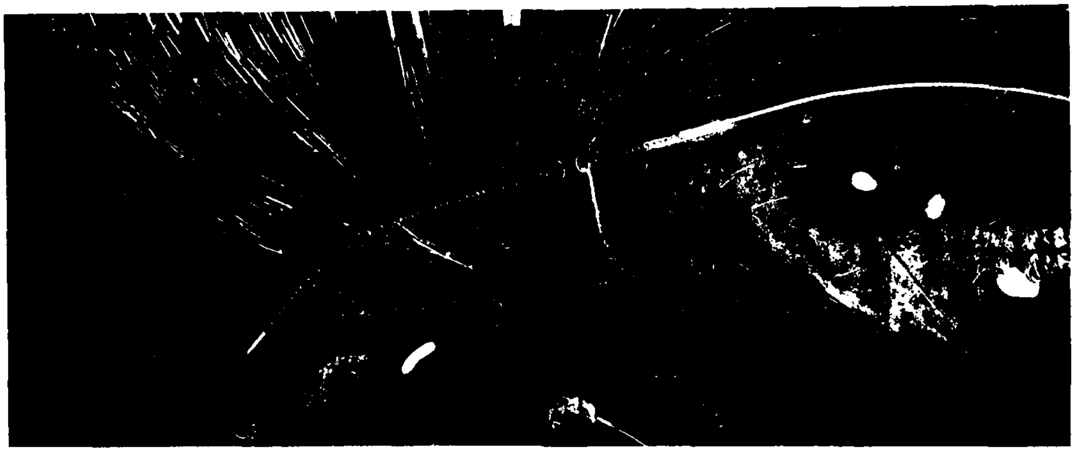
TEST 18

STORM SURGE OF

12 SEPTEMBER 1960

VELOCITY SCALE
10 0 10 20
FT/SEC

SURFACE CURRENT PHOTOGRAPHS
BOTTOM PROTECTION TEST
TEST 18
STORM SURGE OF
1 MARCH 1962



12 SEPT '60

7 MAR '62

VELOCITY SCALE

10 0 10

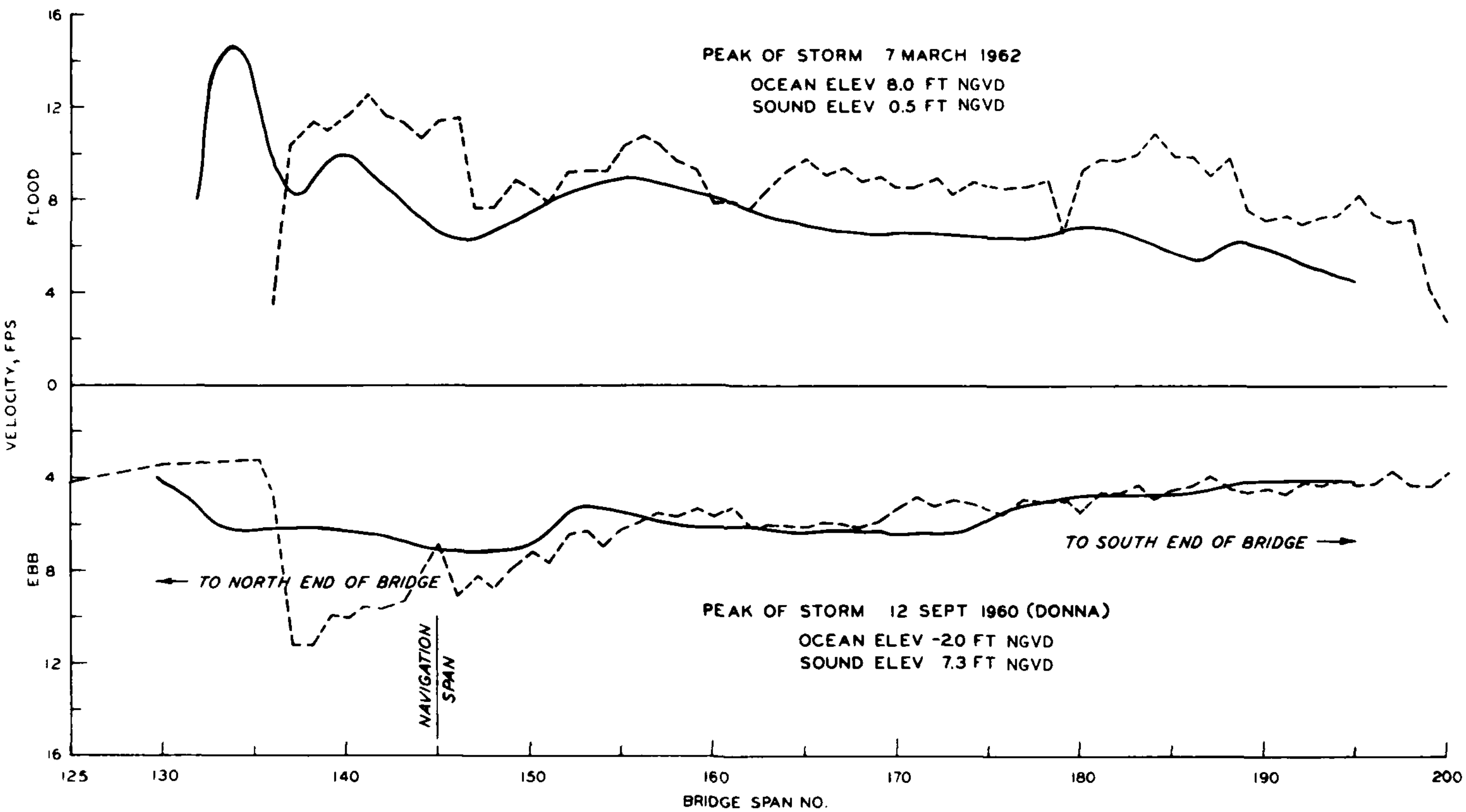
FT/SEC

SURFACE CURRENT
PHOTOGRAPHS

BOTTOM PROTECTION TEST

TEST 18

STORM SURGES



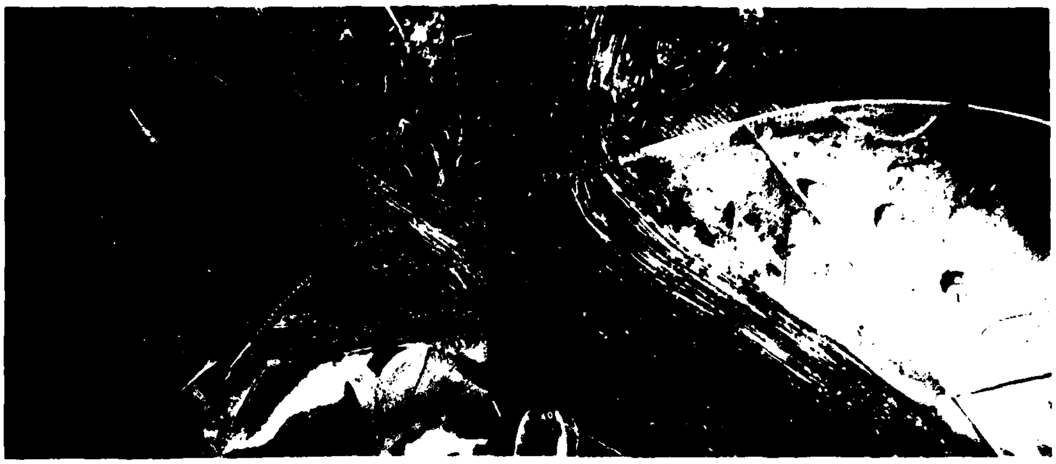
LEGEND

——— BASE TEST-MODEL BUILT TO 1975 SURVEY

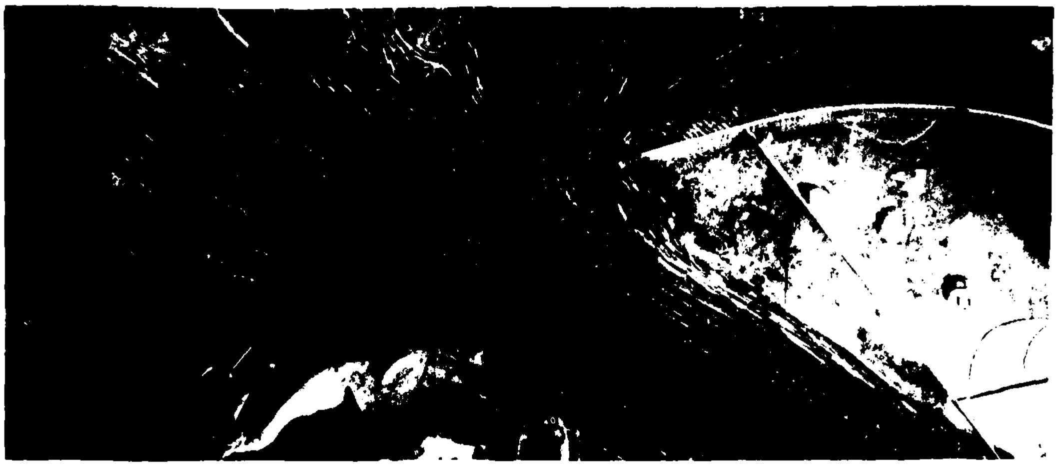
– – – TEST 18

EFFECT OF BOTTOM PROTECTION

STORM SURGE VELOCITIES
AT BONNER BRIDGE
TEST 18



TIME-STEP 1
STRENGTH OF EBB



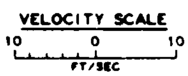
TIME-STEP 16
STRENGTH OF FLOOD

VELOCITY SCALE
5 0 5
FT/SEC

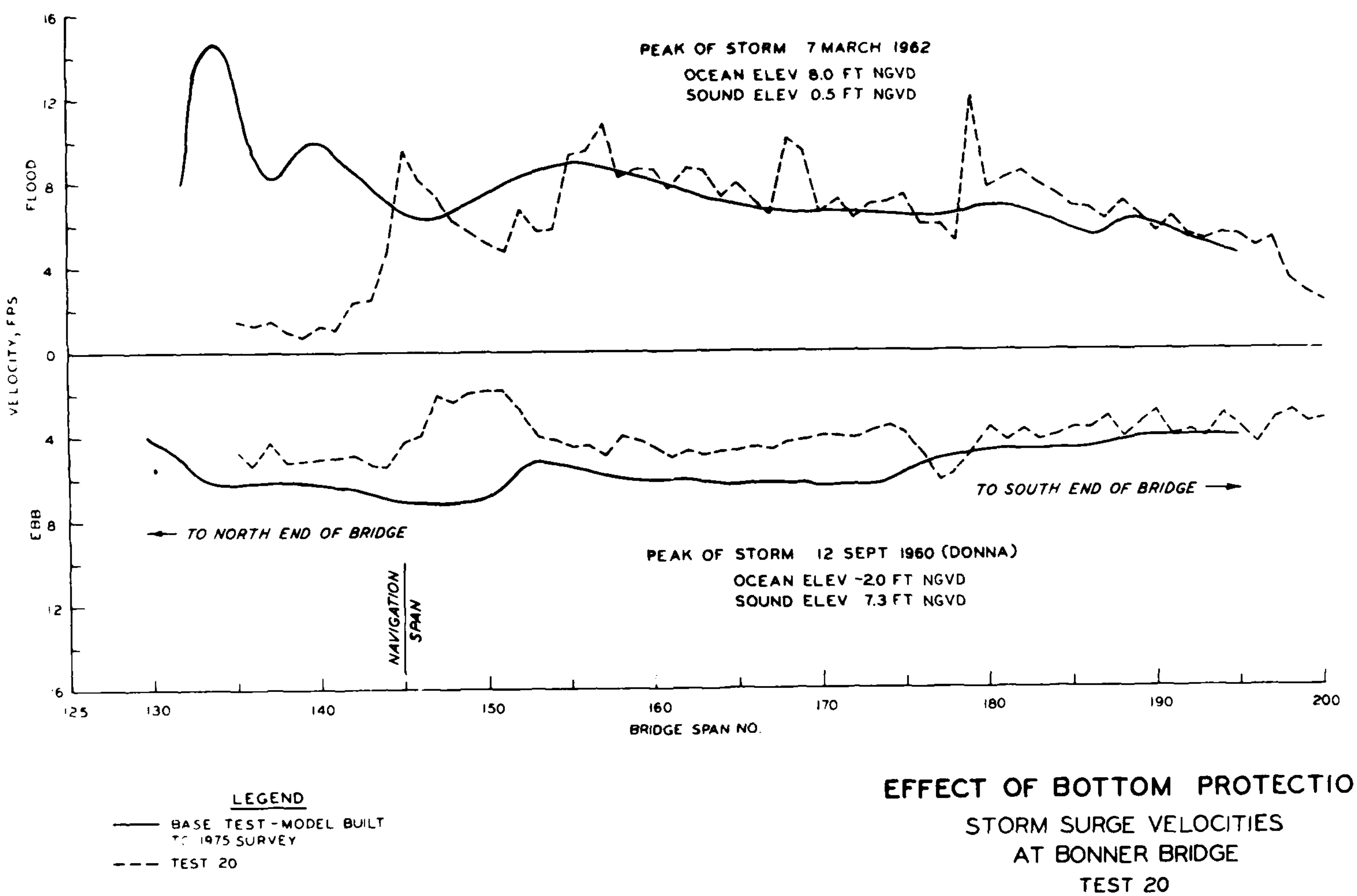
SURFACE CURRENT PHOTOGRAPHS
BOTTOM PROTECTION TEST
TEST 20
NORMAL TIDE

12 SEPT 60

7 MAR 62



SURFACE CURRENT
PHOTOGRAPHS
BOTTOM PROTECTION TEST
TEST 20
STORM SURGES



EFFECT OF BOTTOM PROTECTION

STORM SURGE VELOCITIES
AT BONNER BRIDGE
TEST 20

TIME-STEP 1
STRENGTH OF EBB

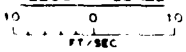
TIME-STEP 16
STRENGTH OF FLOOD

VELOCITY SCALE
5 0 5
FT/SEC

SURFACE CURRENT PHOTOGRAPHS
BOTTOM PROTECTION TEST
TEST 21
NORMAL TIDE

12 SEPT 60

7 MAR 62

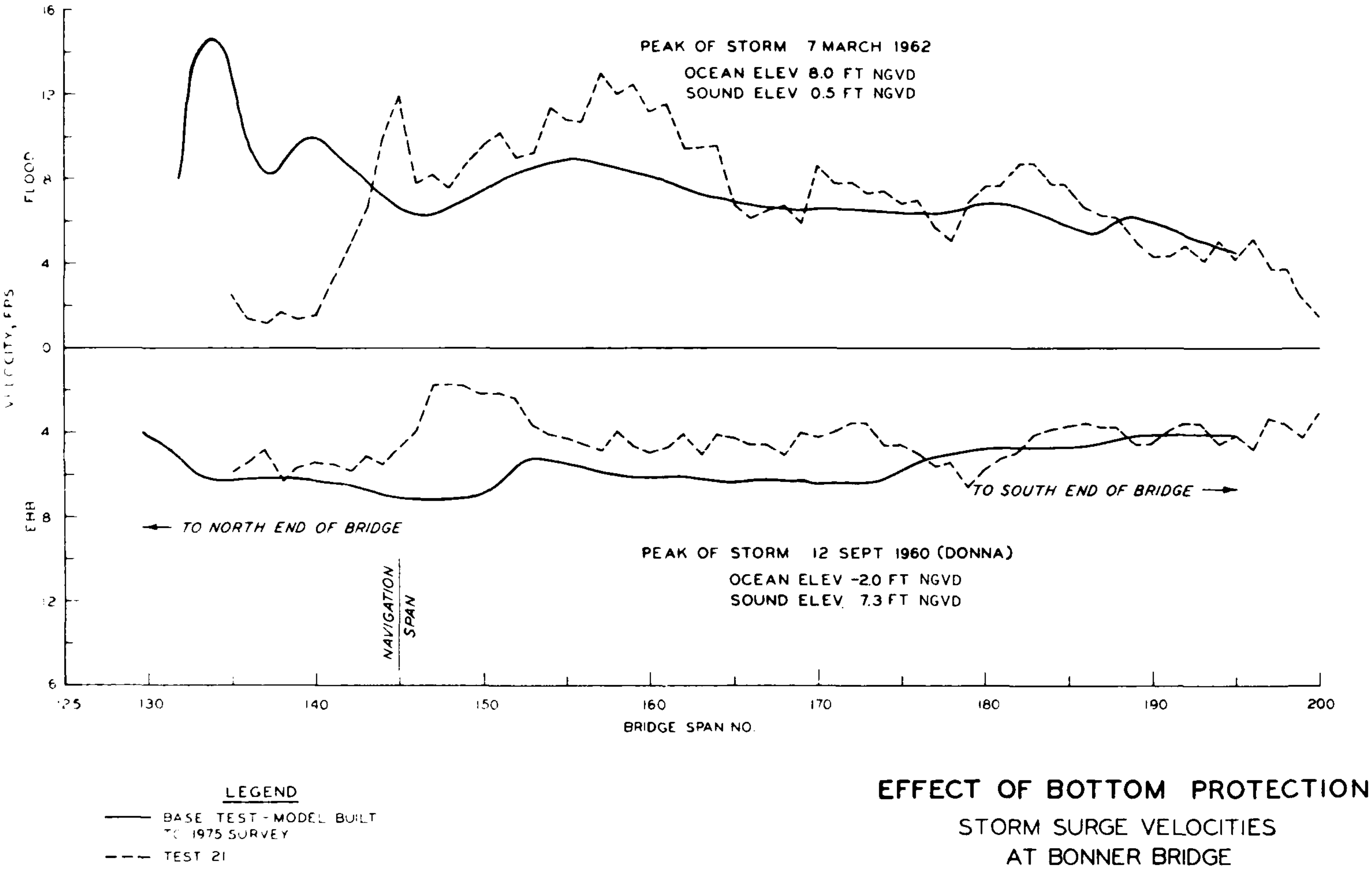


SURFACE CURRENT
PHOTOGRAPHS

BOTTOM PROTECTION TEST

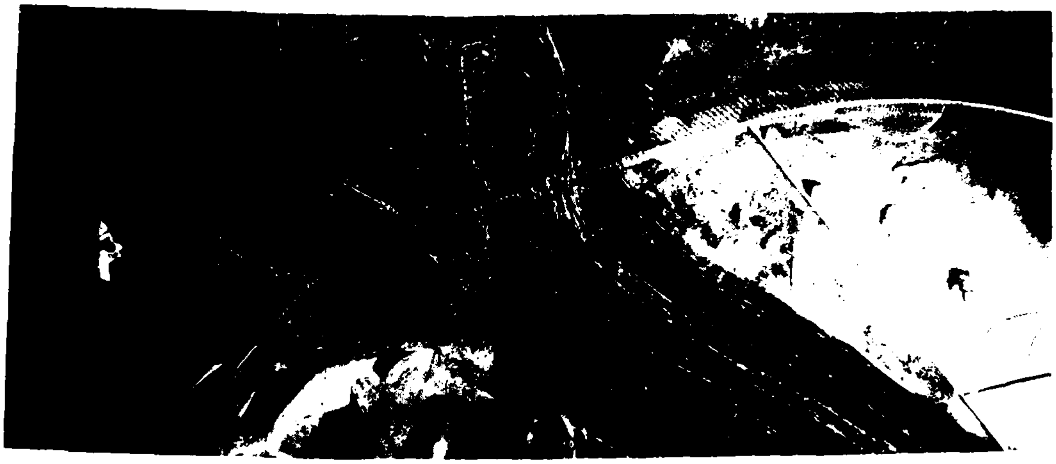
TEST 21

STORM SURGES



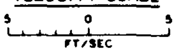
EFFECT OF BOTTOM PROTECTION

STORM SURGE VELOCITIES
AT BONNER BRIDGE
TEST 21



TIME-STEP 1
STRENGTH OF EBB

TIME-STEP 16
STRENGTH OF FLOOD



SURFACE CURRENT
PHOTOGRAPHS

BOTTOM PROTECTION TEST

TEST 22

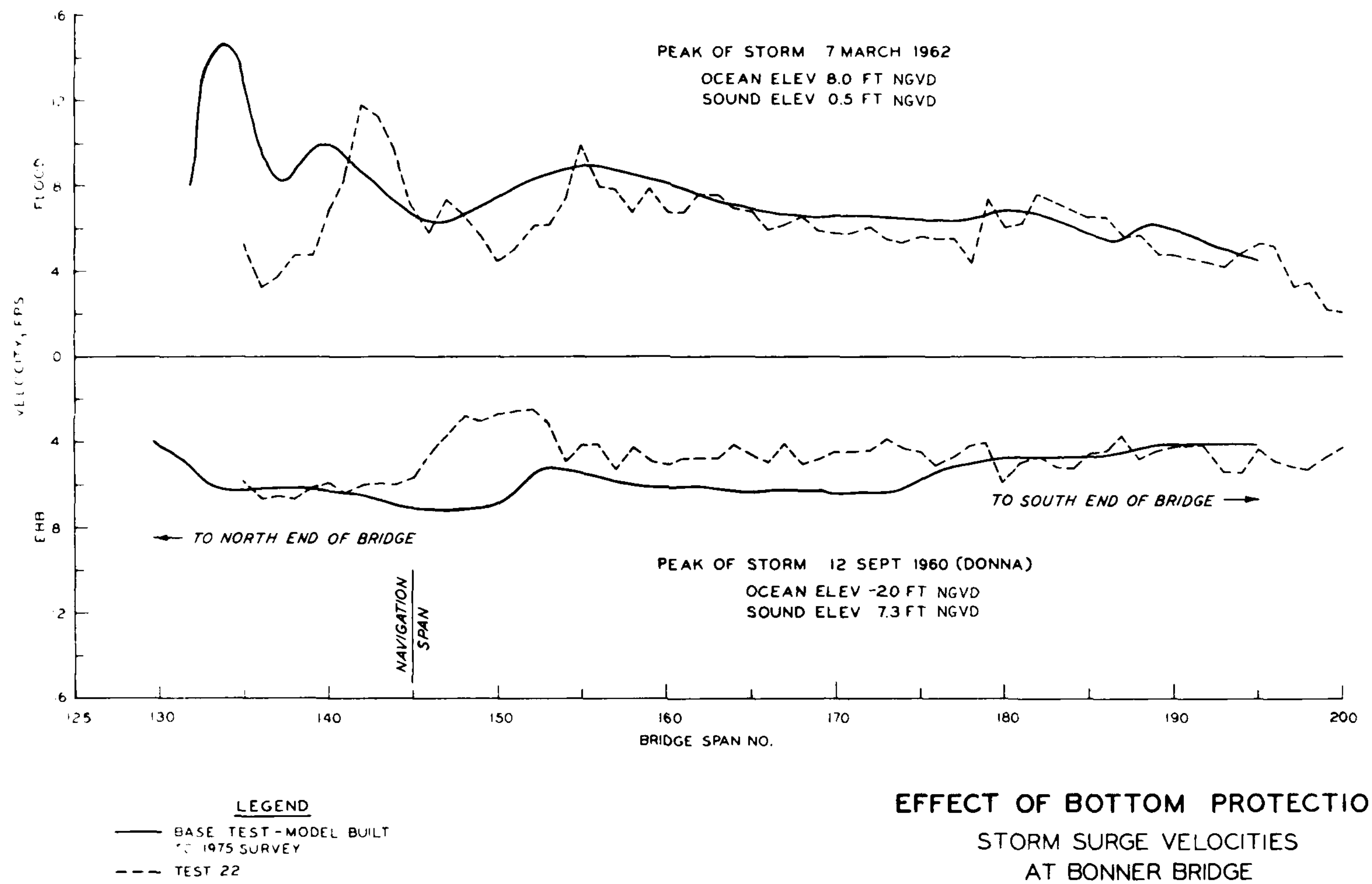
NORMAL TIDE

12 SEPT 60

7 MAR 62

VELOCITY SCALE
10 0 10
FT/SEC

SURFACE CURRENT PHOTOGRAPHS
BOTTOM PROTECTION TEST
TEST 22
STORM SURGES



EFFECT OF BOTTOM PROTECTION

STORM SURGE VELOCITIES
AT BONNER BRIDGE
TEST 22

TIME-STEP 1
STRENGTH OF EBB

TIME-STEP 16
STRENGTH OF FLOOD

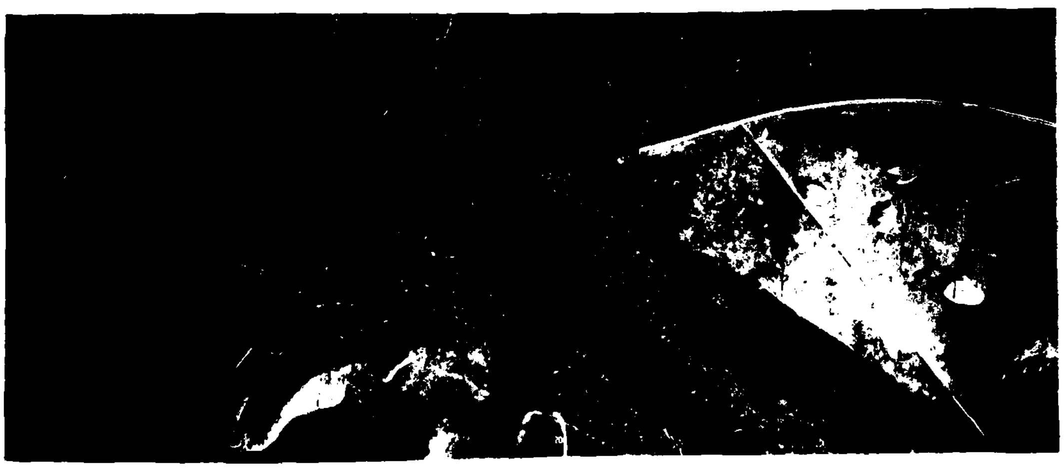
SURFACE CURRENT PHOTOGRAPHS

BOTTOM PROTECTION TEST

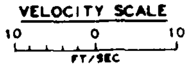
TEST 24

NORMAL TIDE

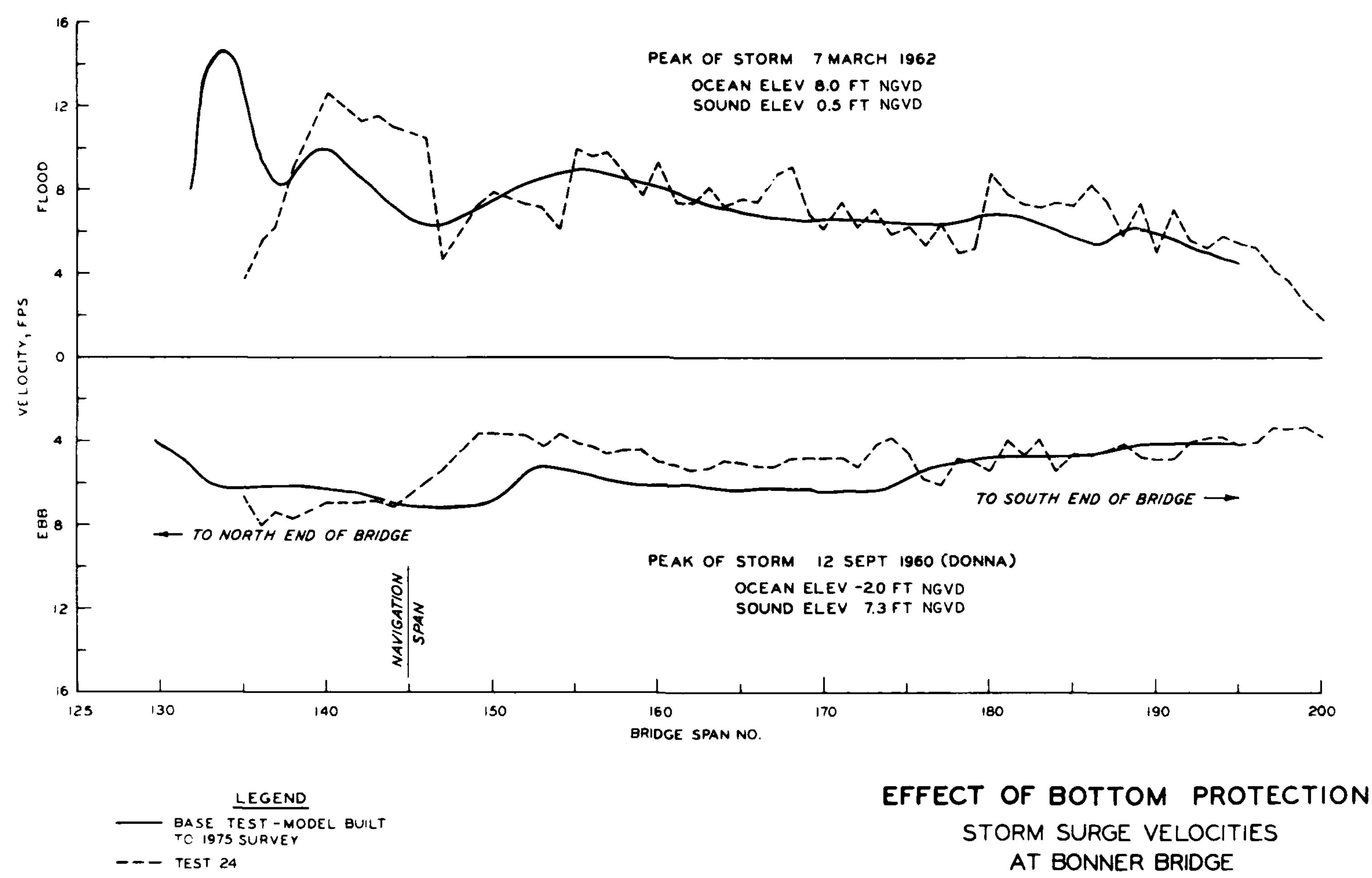
12 SEPT 60



7 MAR 62



SURFACE CURRENT
PHOTOGRAPHS
BOTTOM PROTECTION TEST
TEST 24
STORM SURGES



EFFECT OF BOTTOM PROTECTION

STORM SURGE VELOCITIES
AT BONNER BRIDGE
TEST 24

TIME-STEP 1
STRENGTH OF EBB

TIME-STEP 16
STRENGTH OF FLOOD

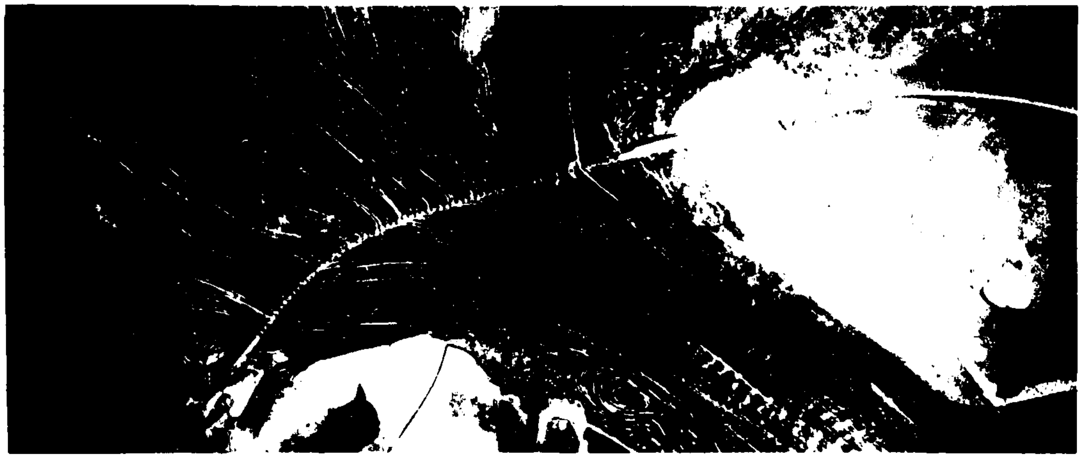
VELOCITY SCALE

FT/SEC

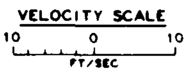
SURFACE CURRENT
PHOTOGRAPHS

BOTTOM PROTECTION TEST
TEST 26
NORMAL TIDE

12 SEPT '60



7 MAR '62



SURFACE CURRENT
PHOTOGRAPHS
BOTTOM PROTECTION TEST
TEST 26
STORM SURGES

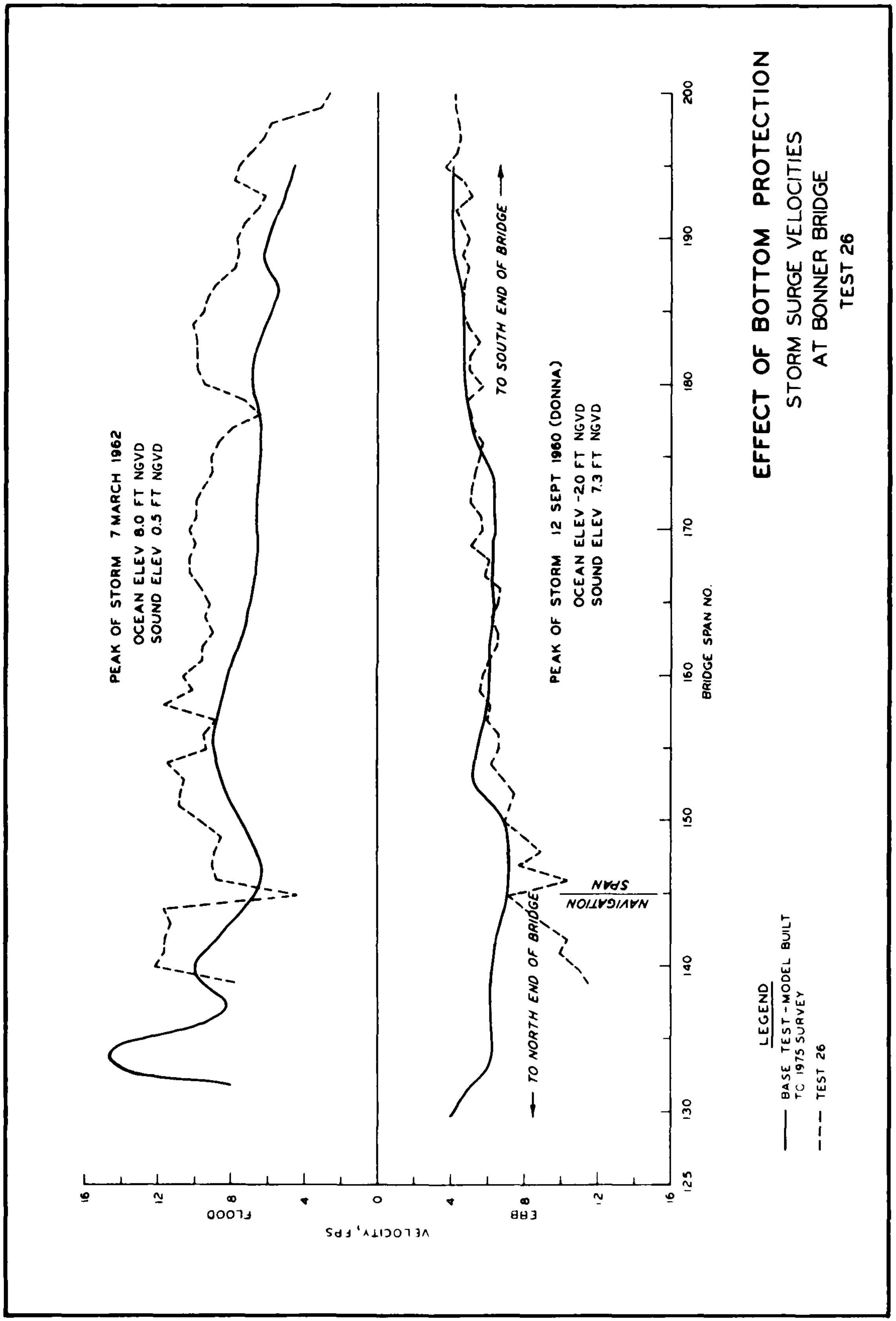
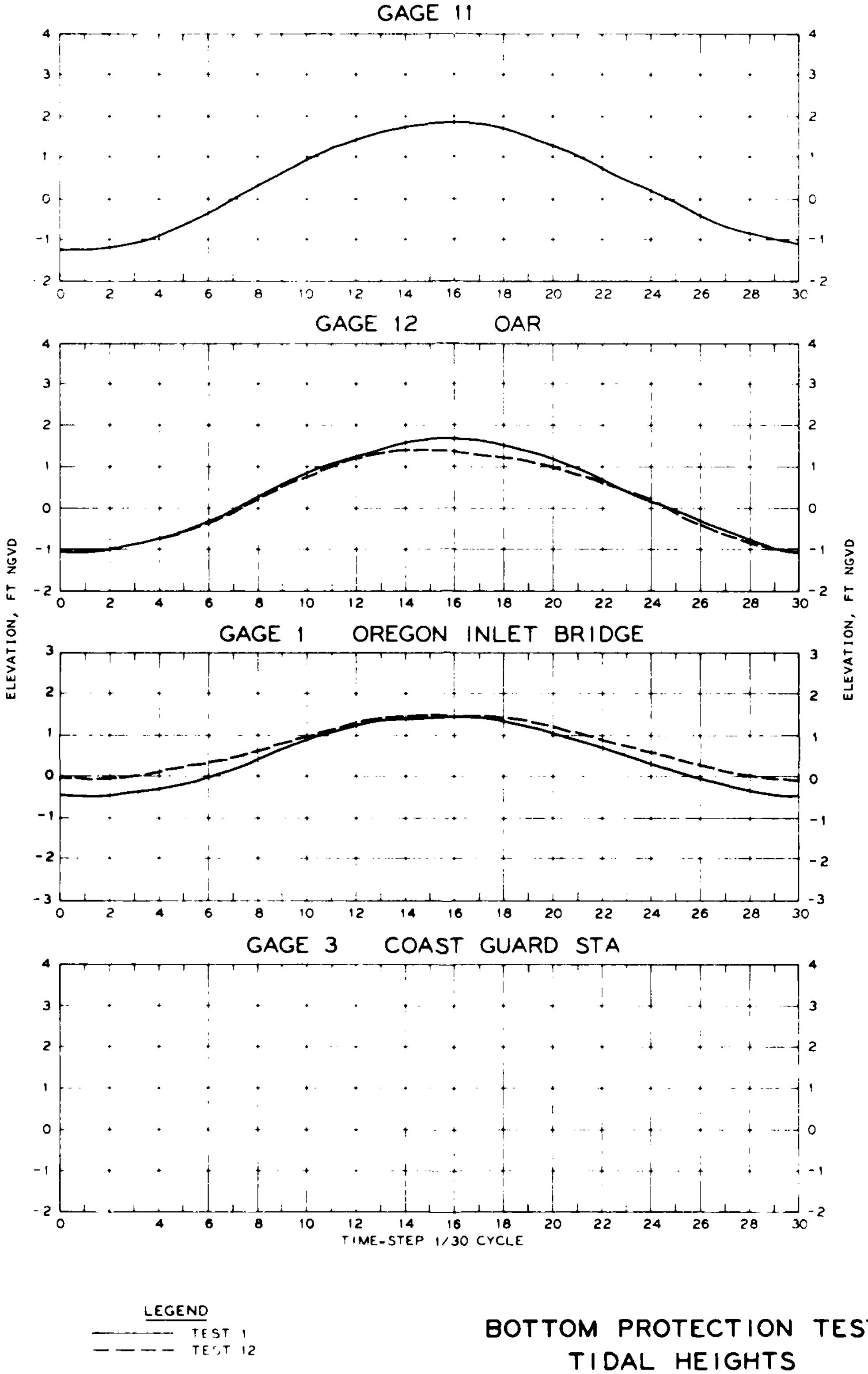
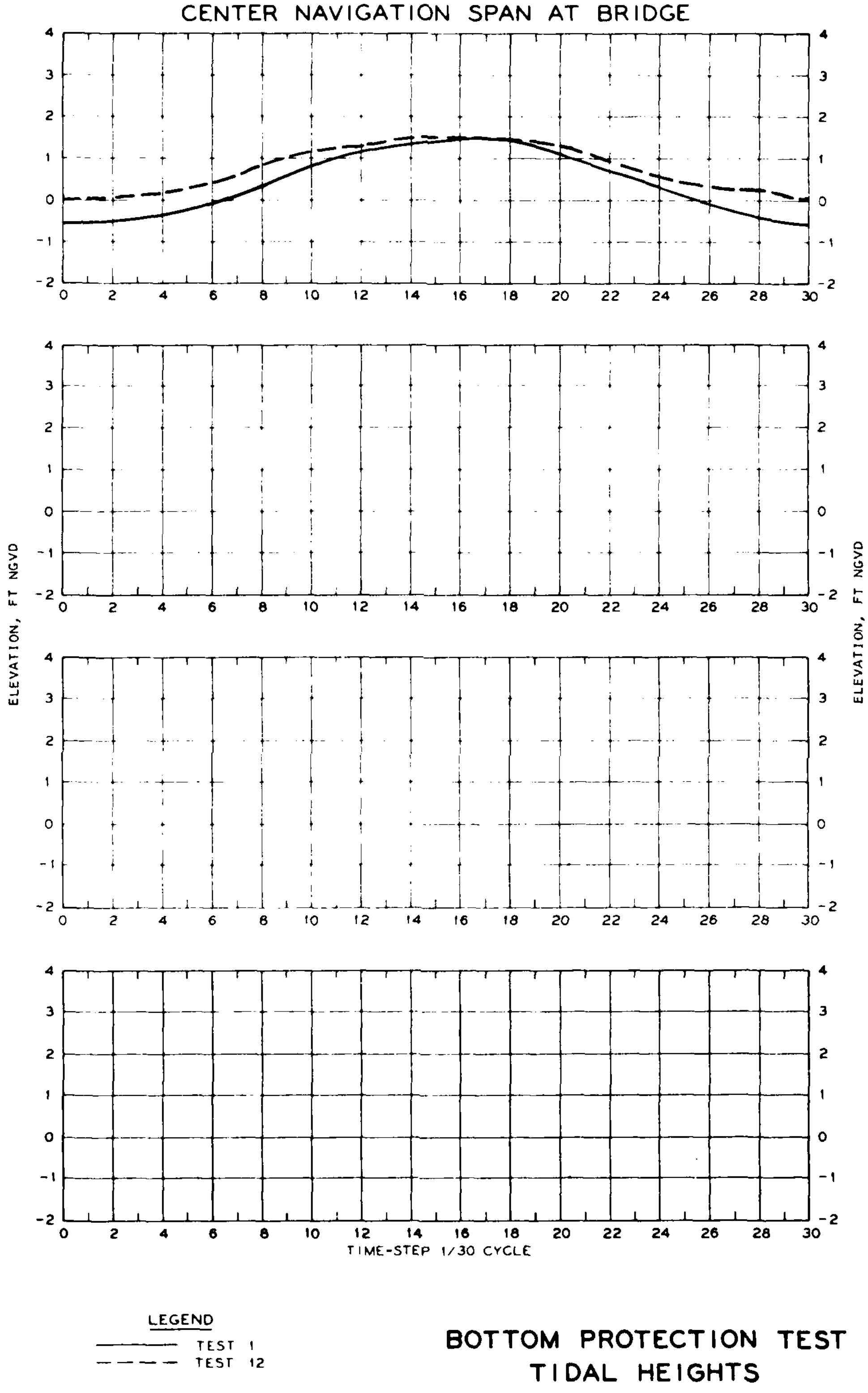

EFFECT OF BOTTOM PROTECTION
STORM SURGE VELOCITIES
AT BONNER BRIDGE
TEST 26
PEAK OF STORM 7 MARCH 1962
OCEAN ELEV 6.0 FT NGVD
SOUND ELEV 0.5 FT NGVD
PEAK OF STORM 12 SEPT 1960 (DONNA)
OCEAN ELEV -2.0 FT NGVD
SOUND ELEV 7.3 FT NGVD
TO SOUTH END OF BRIDGE
TO NORTH END OF BRIDGE
NAVIGATION SPAN
FLOOD
EBB
VELOCITY, FPS
BRIDGE SPAN NO.
LEGEND
BASE TEST-MODEL BUILT TC 1975 SURVEY
TEST 26

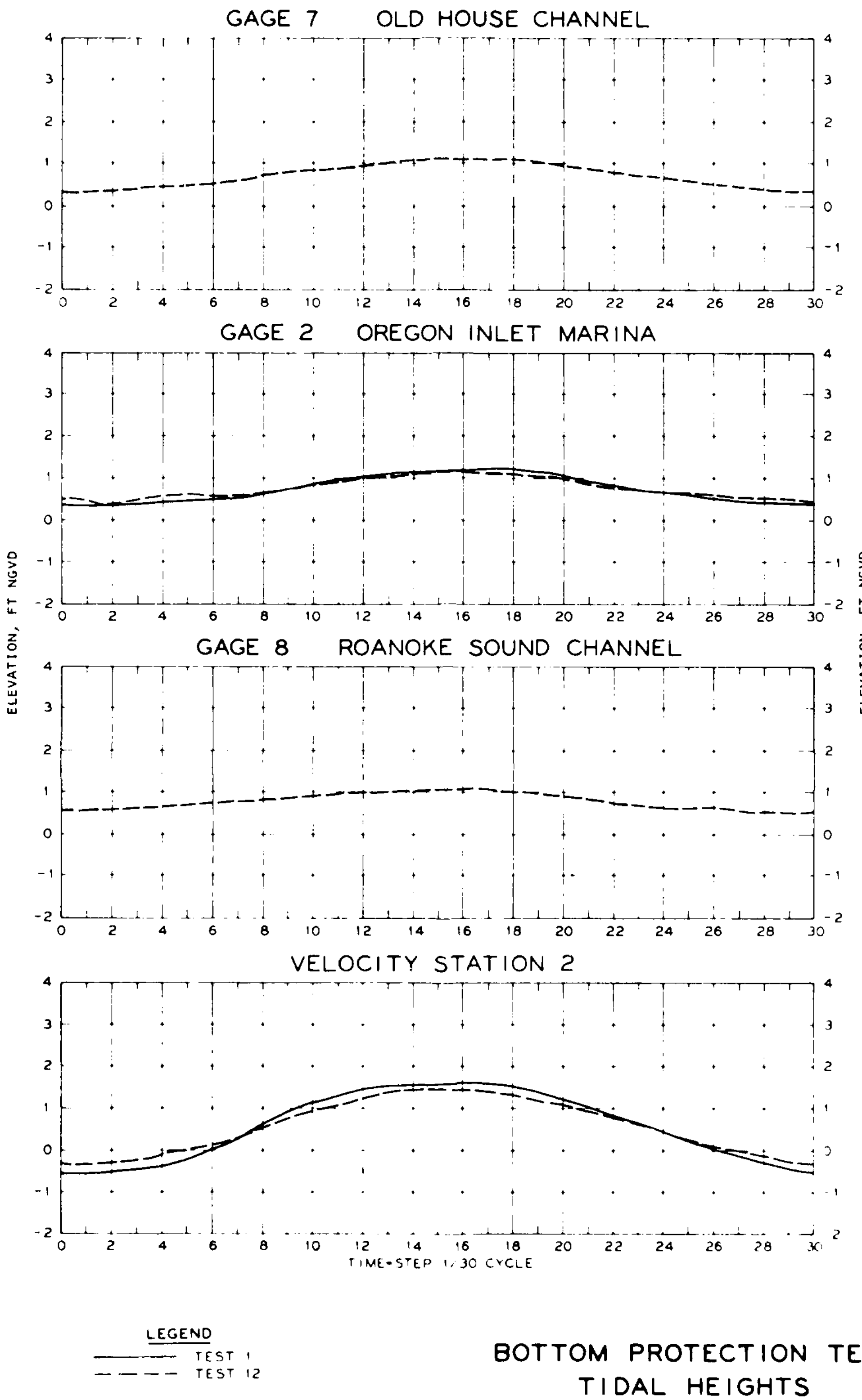
PLATE 182



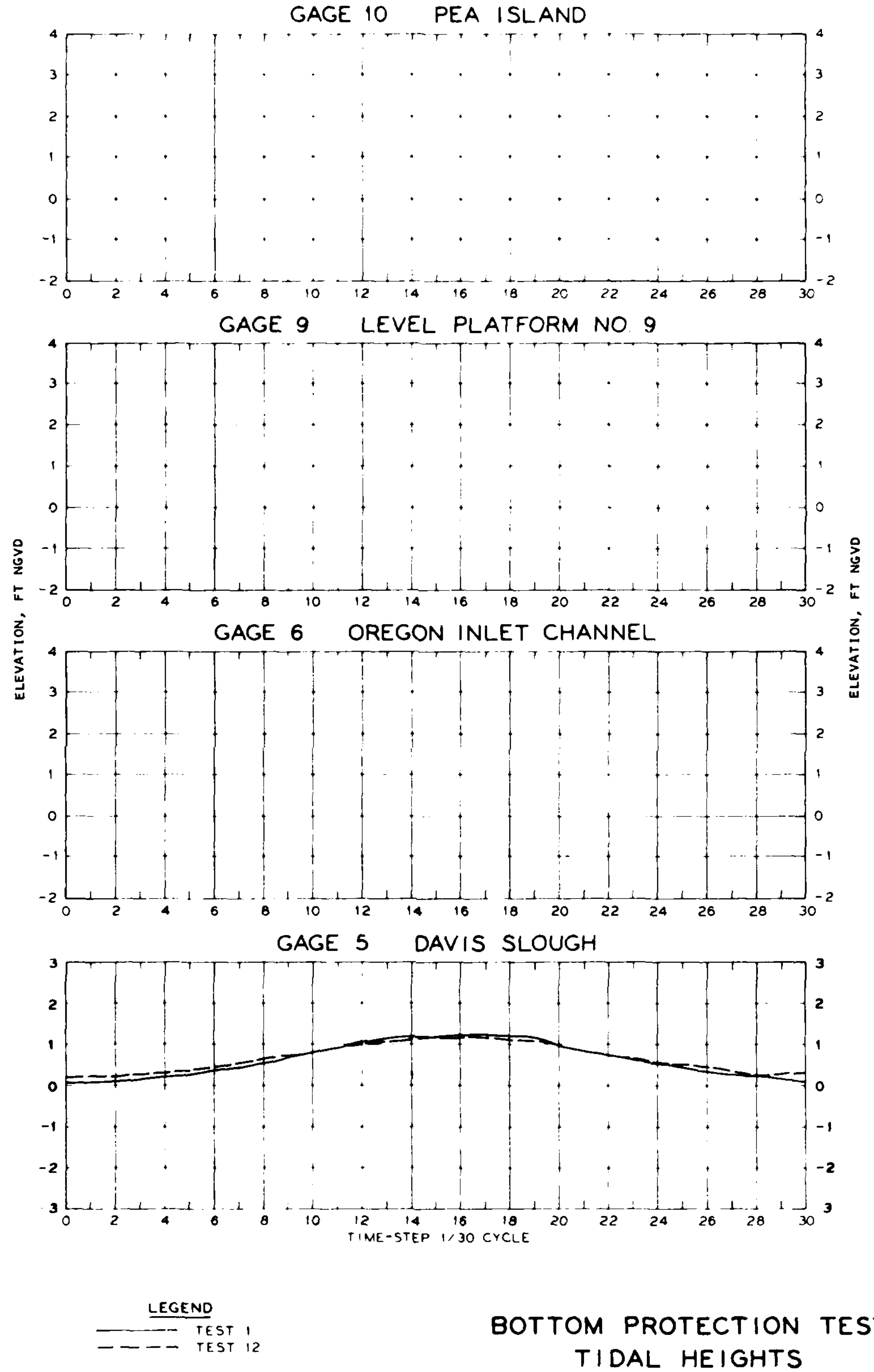
BOTTOM PROTECTION TEST
TIDAL HEIGHTS
TEST 1 VS 12
GAGES 11, 12, 1, AND 3



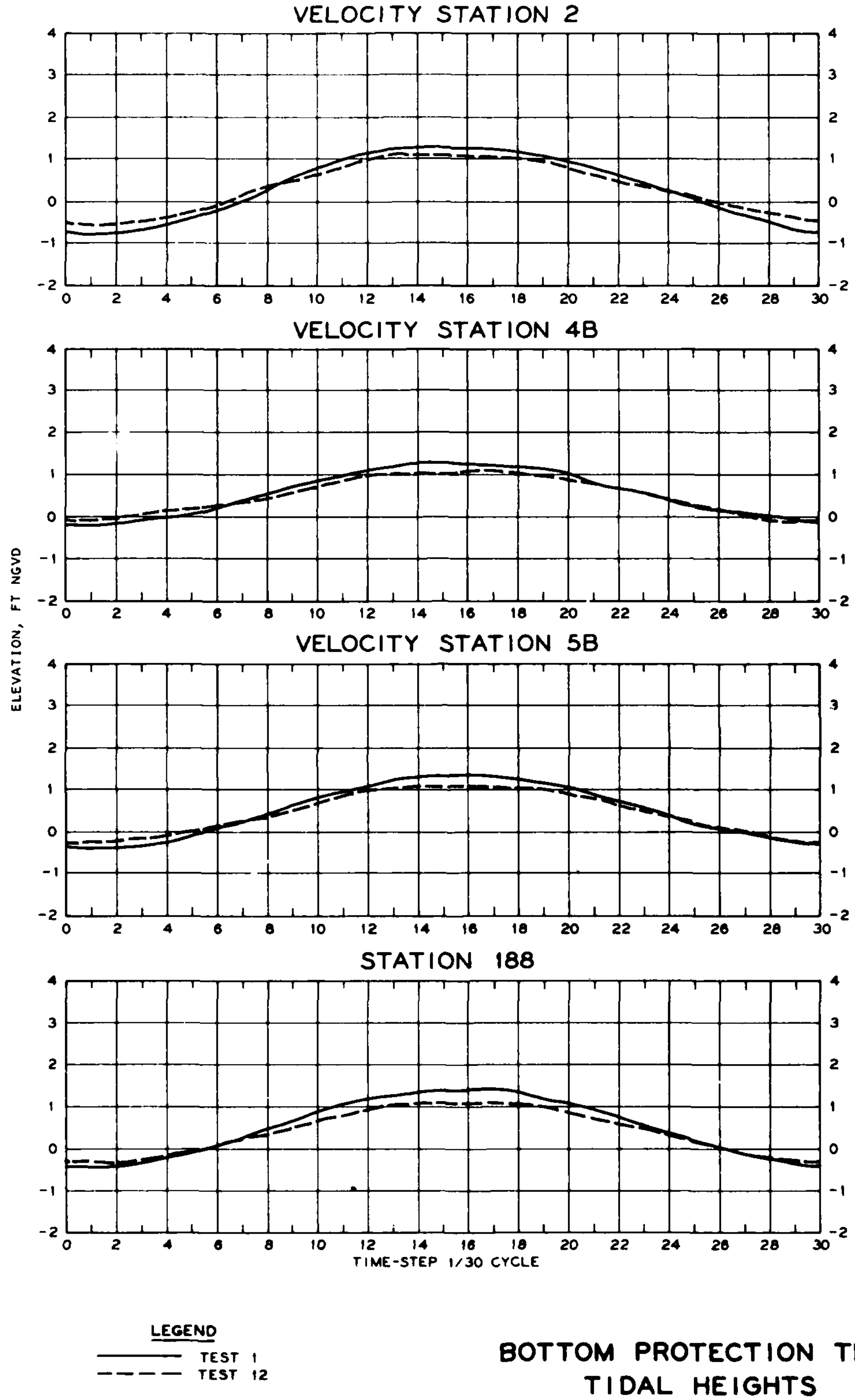
BOTTOM PROTECTION TEST
TIDAL HEIGHTS
TEST 1 VS 12
CENTER NAVIGATION CHANNEL AT BRIDGE



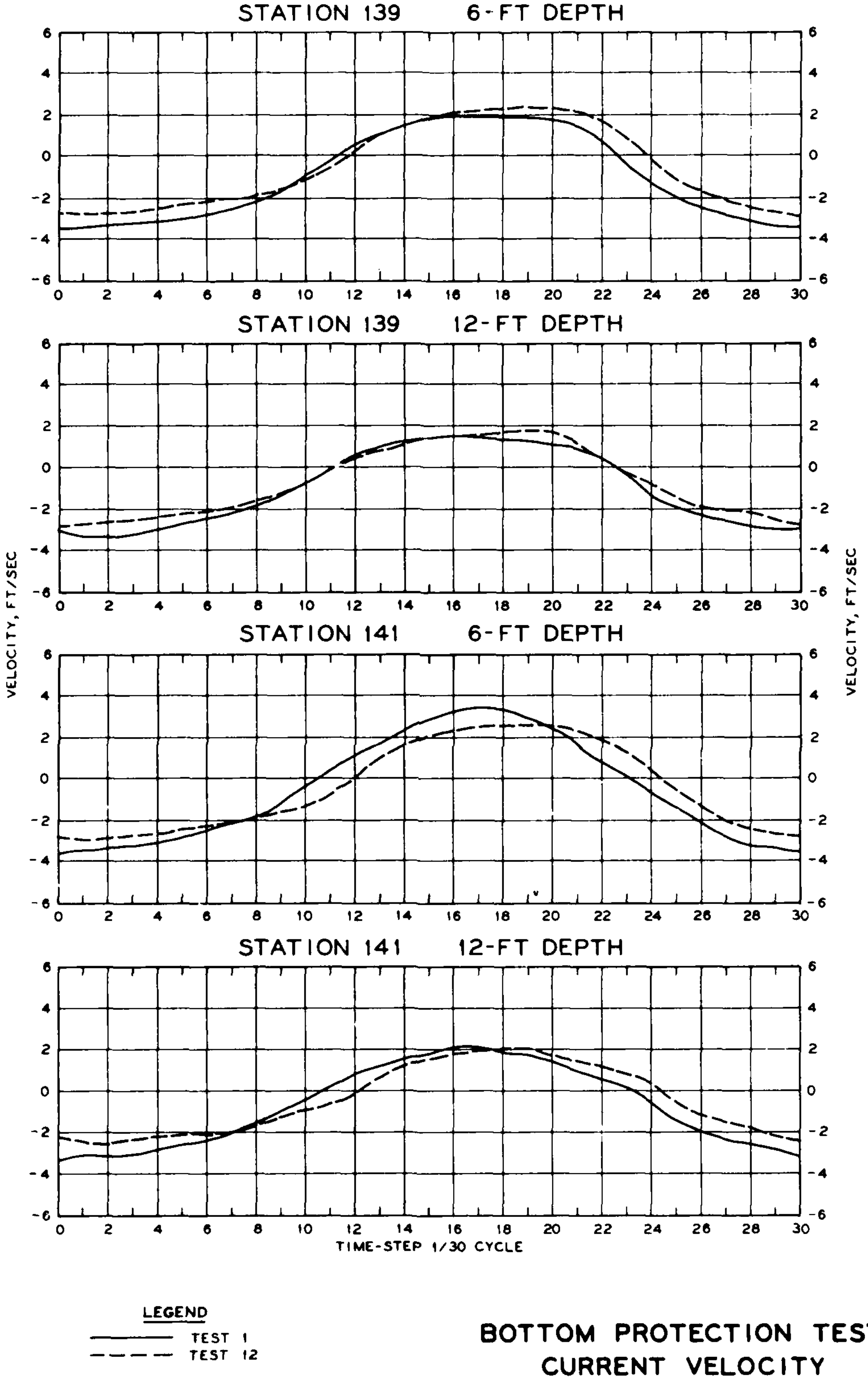
BOTTOM PROTECTION TEST
TIDAL HEIGHTS
TEST 1 VS 12
GAGES 7, 2, AND 8



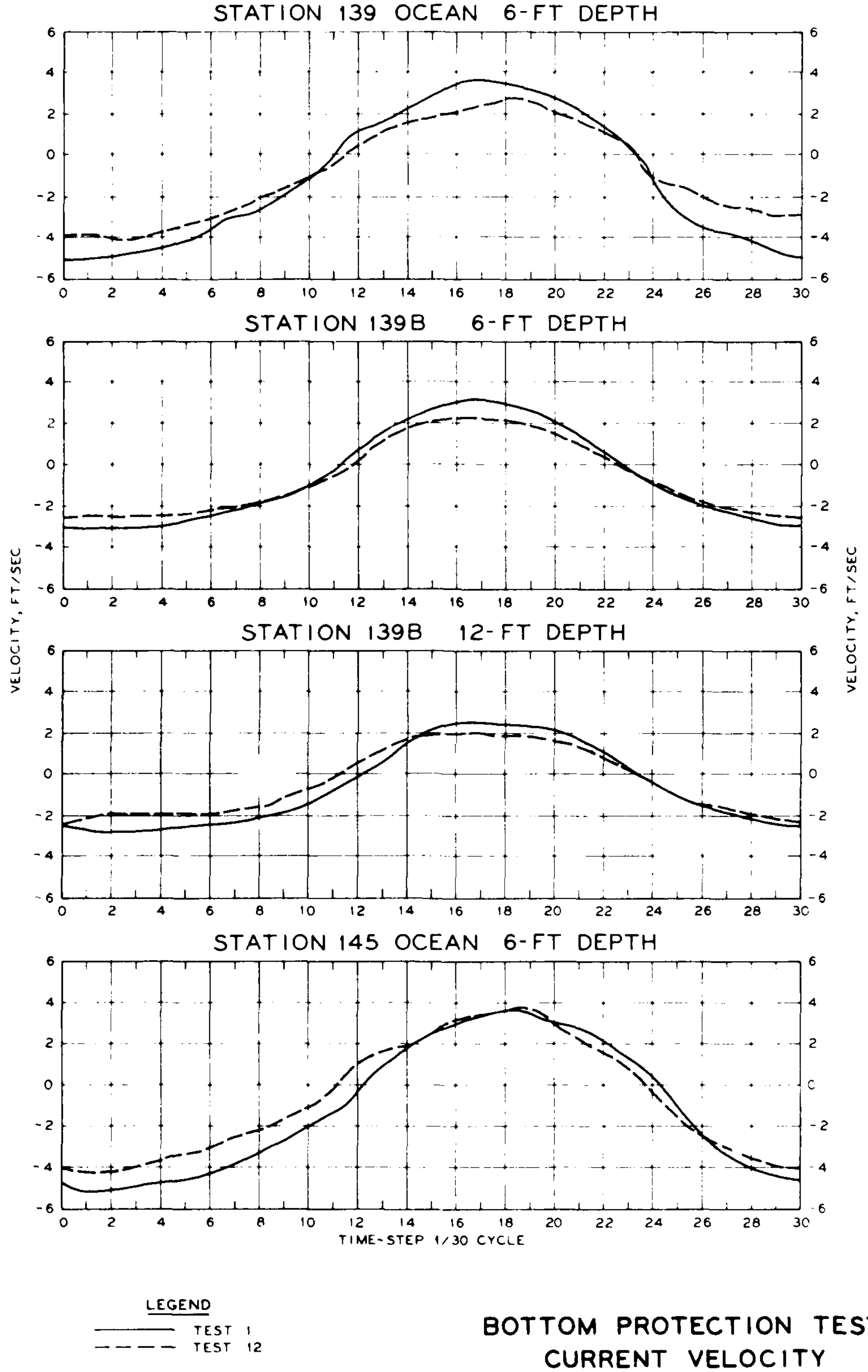
BOTTOM PROTECTION TEST
TIDAL HEIGHTS
TEST 1 VS 12
GAGES 10, 9, 6, AND 5



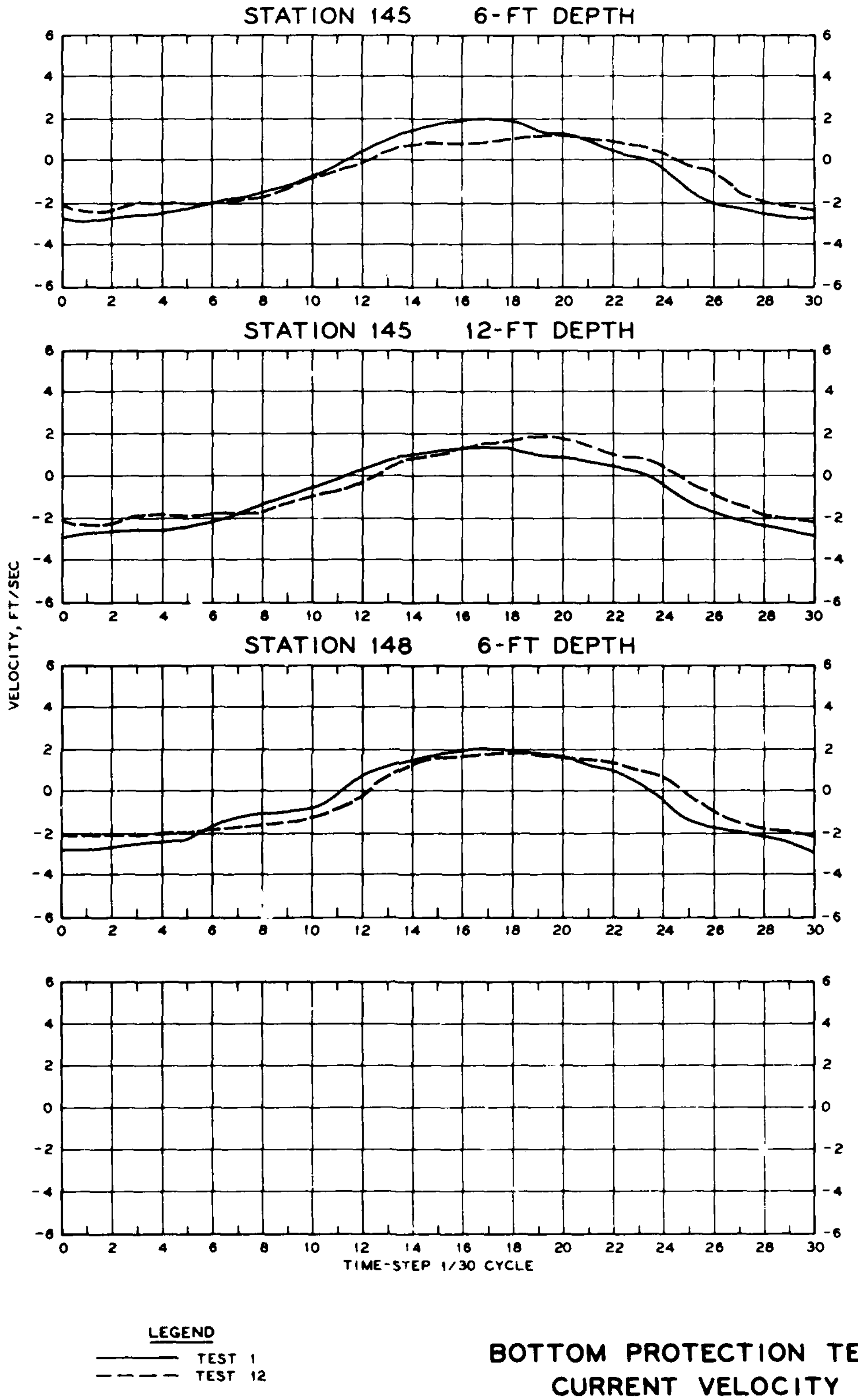
BOTTOM PROTECTION TEST
TIDAL HEIGHTS
TEST 1 VS 12
STATIONS 2, 4B, 5B, AND 188



BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 1 VS 12
STATIONS 139 AND 141



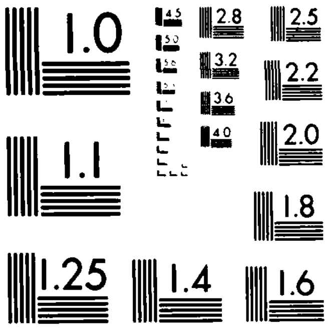
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 1 VS 12
STATIONS 139 AND 145



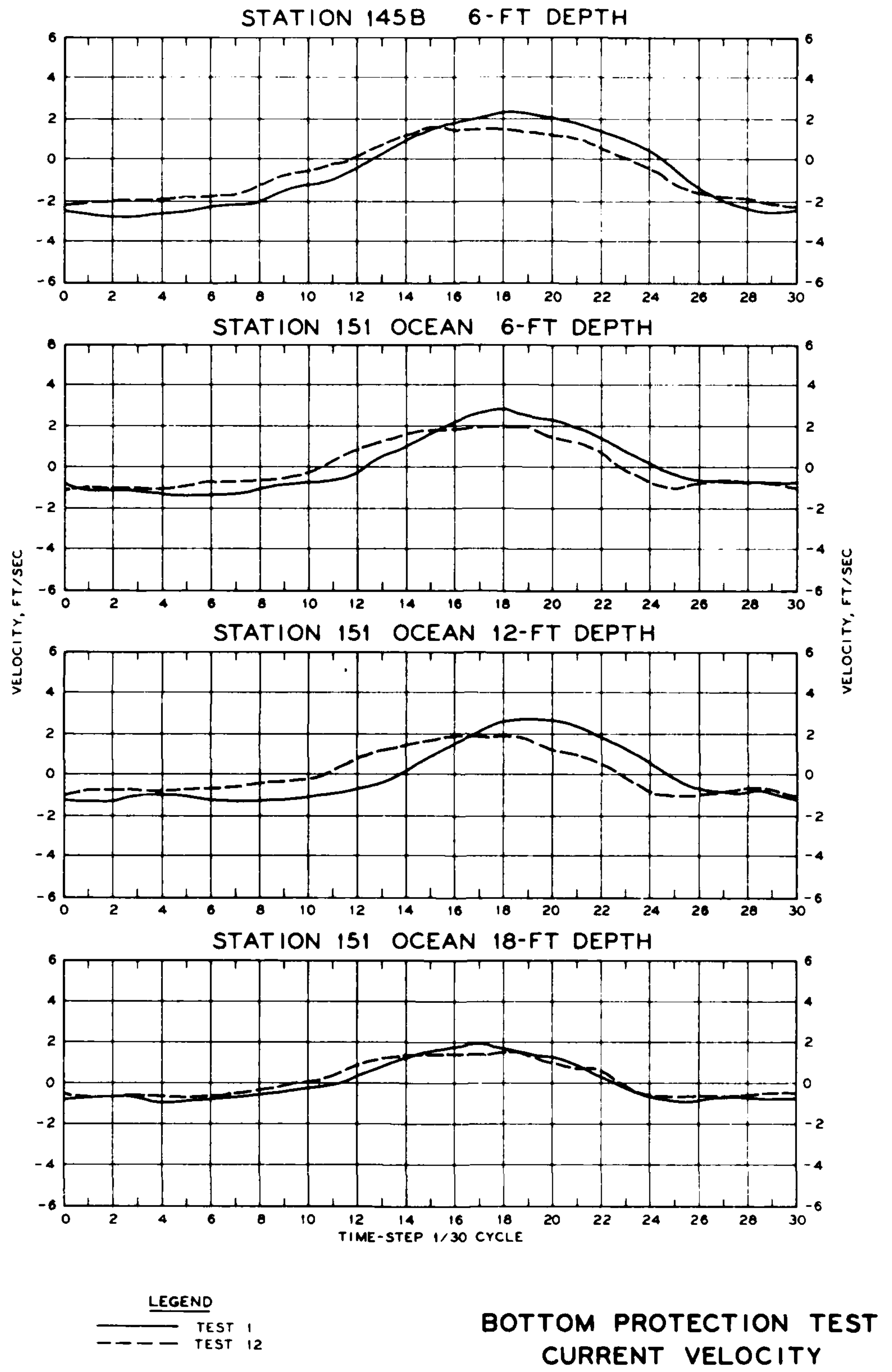
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 1 VS 12
STATIONS 145 AND 148

AD-A131 999 HYDRAULIC MODEL INVESTIGATION: FUNCTIONAL DESIGN OF CONTROL STRUCTURES FO..(U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS HYDRA.. 46

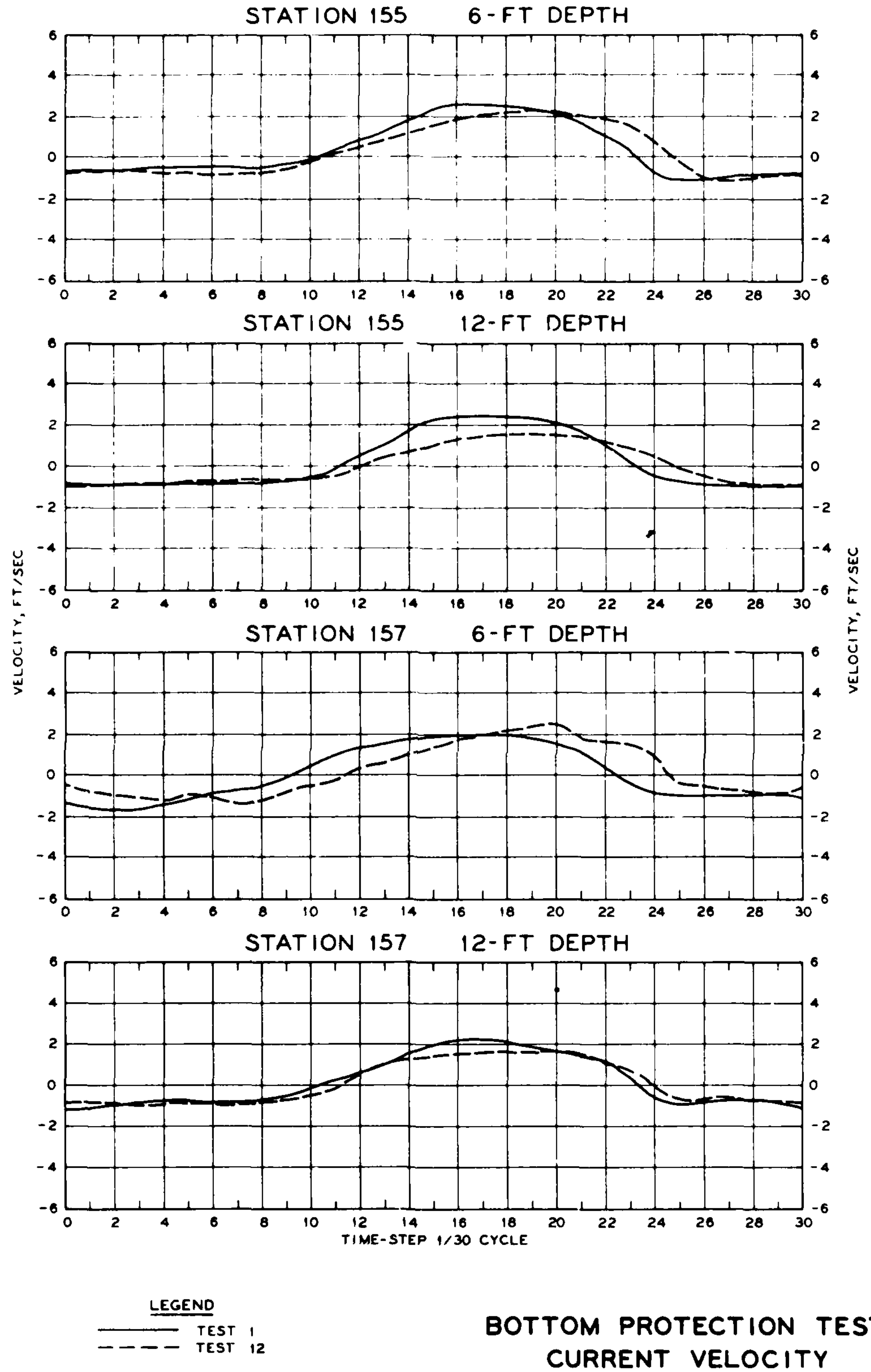
UNCLASSIFIED N W HOLLYFIELD ET AL. JUN 83 F/G 8/3 NL



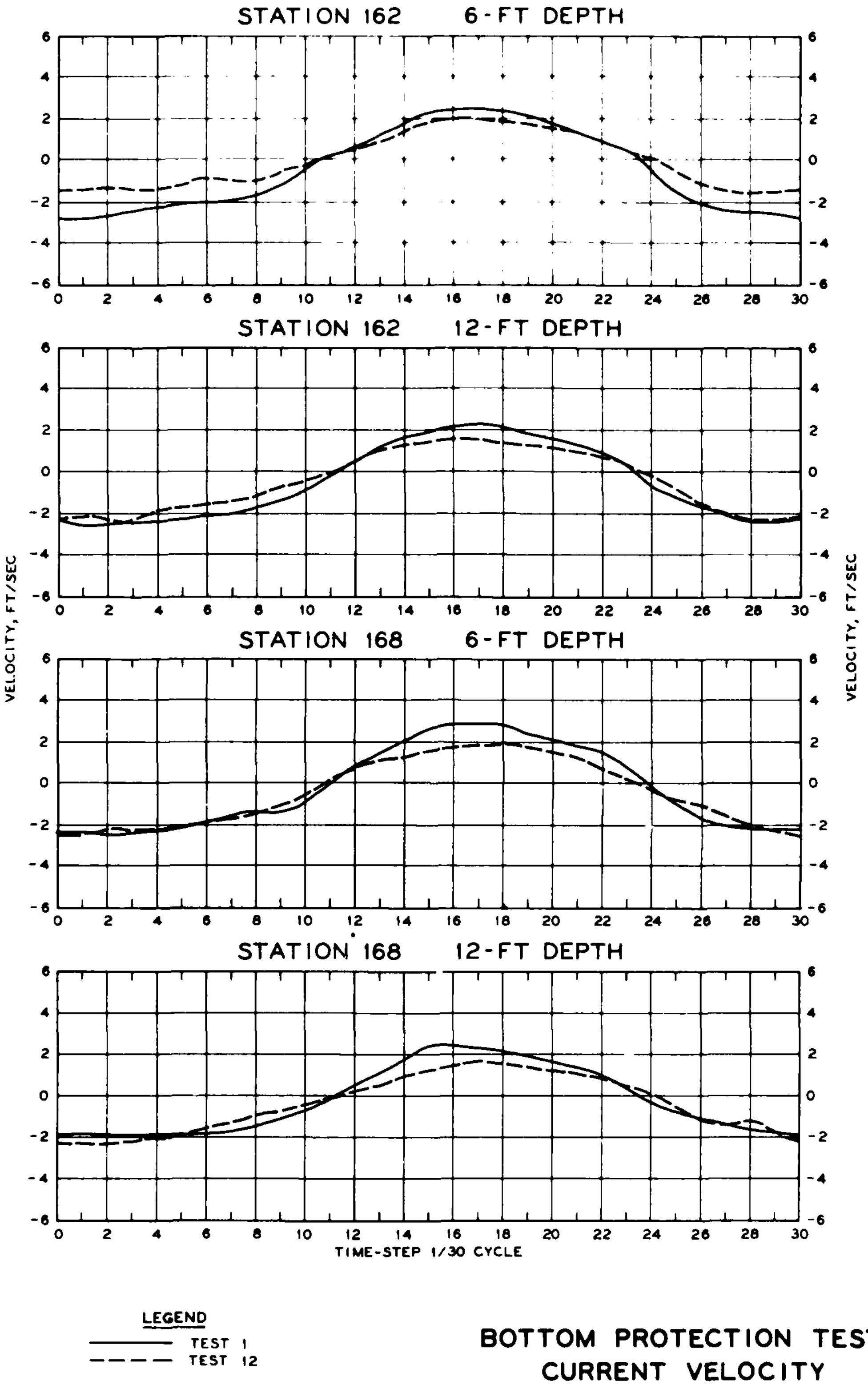
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



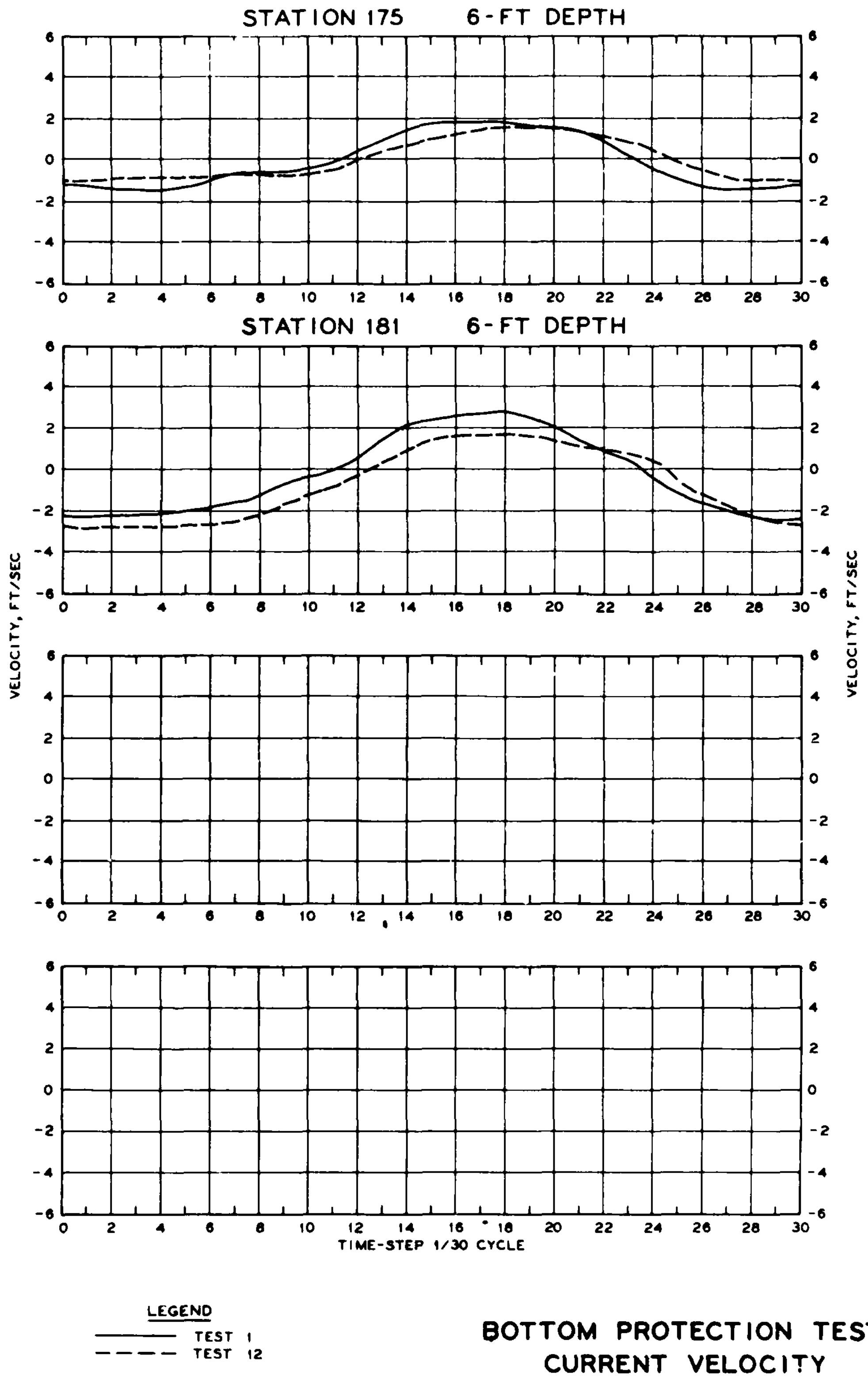
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 1 VS 12
STATIONS 145 AND 151



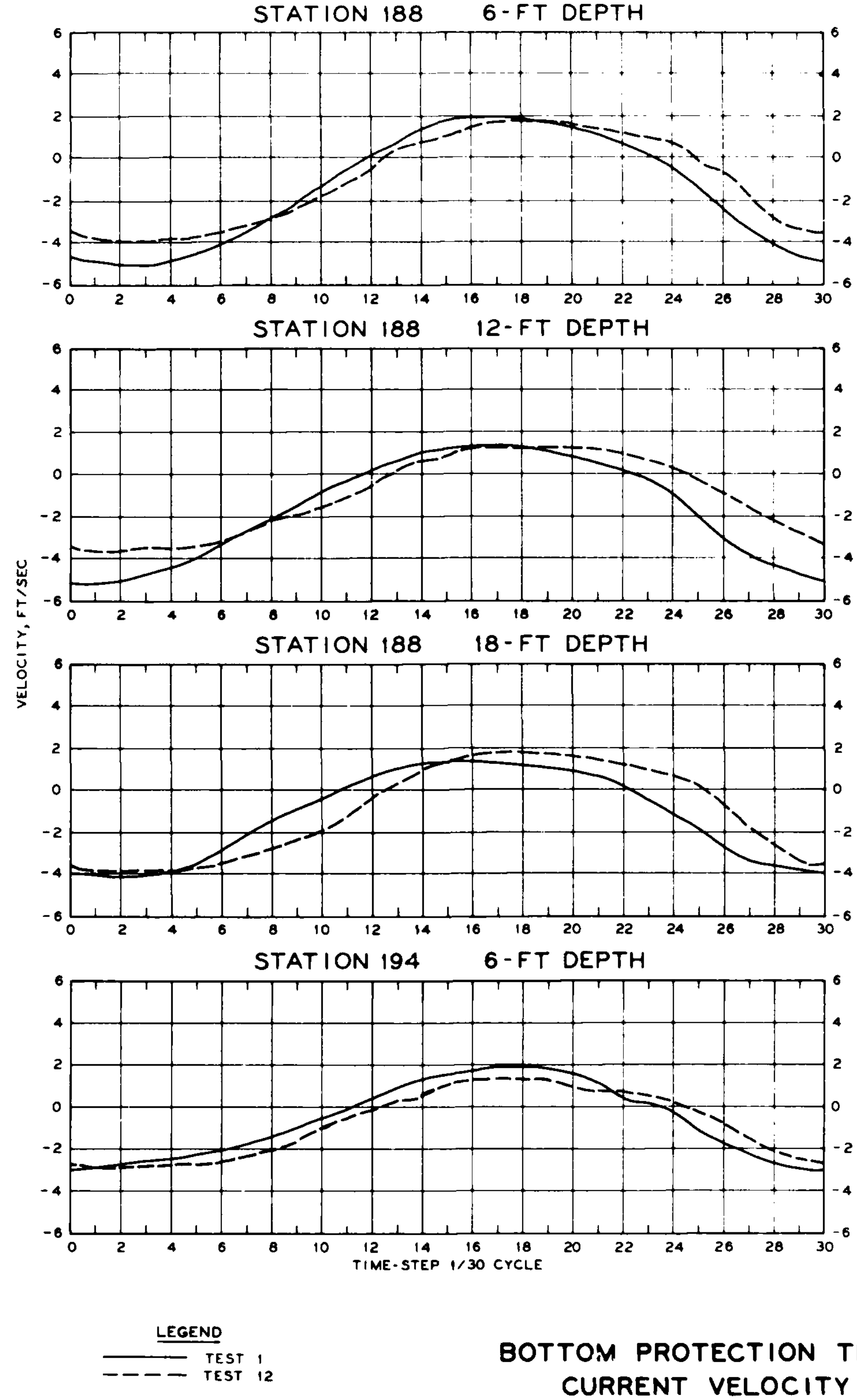
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 1 VS 12
STATIONS 155 AND 157



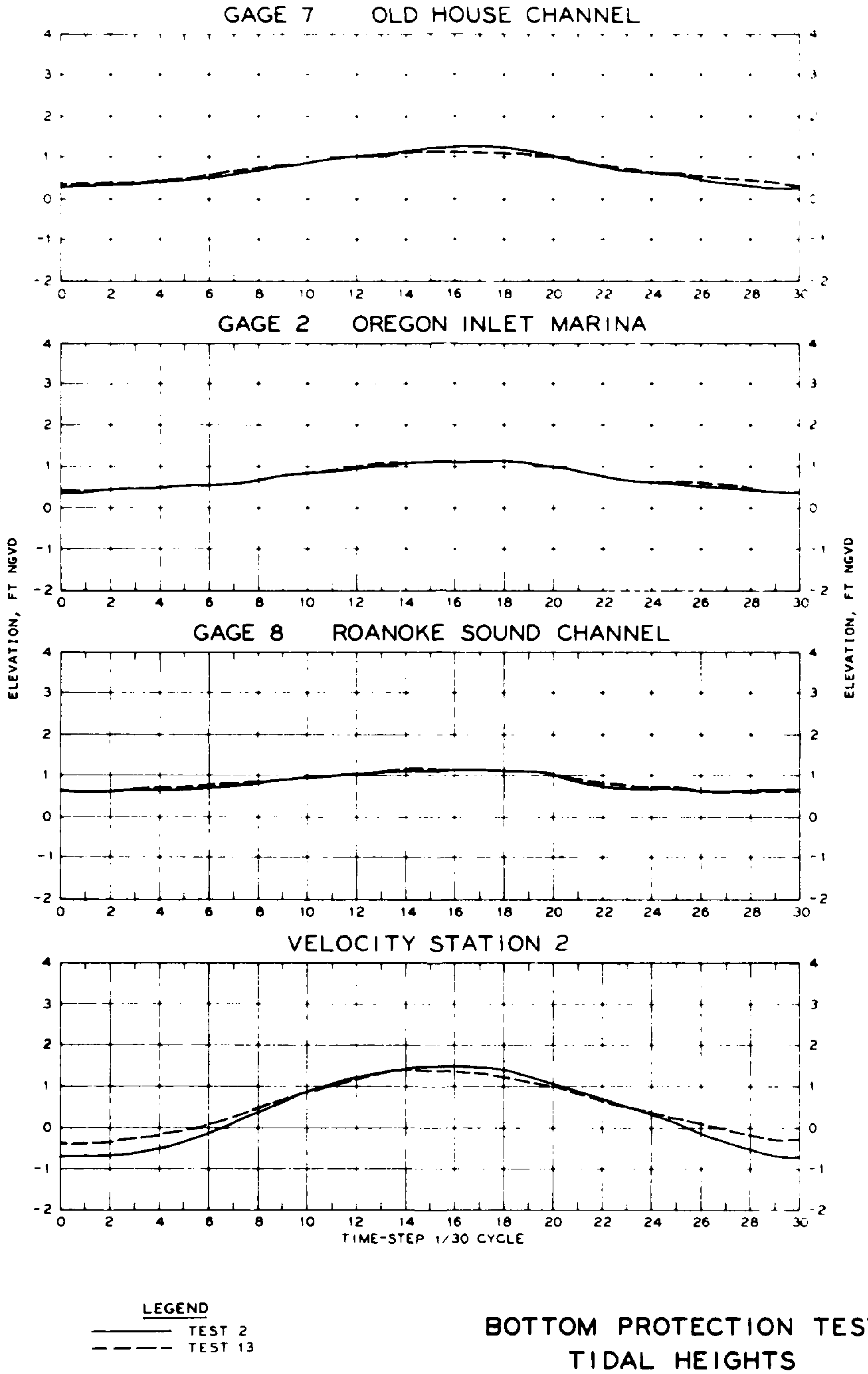
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 1 VS 12
STATIONS 162 AND 168



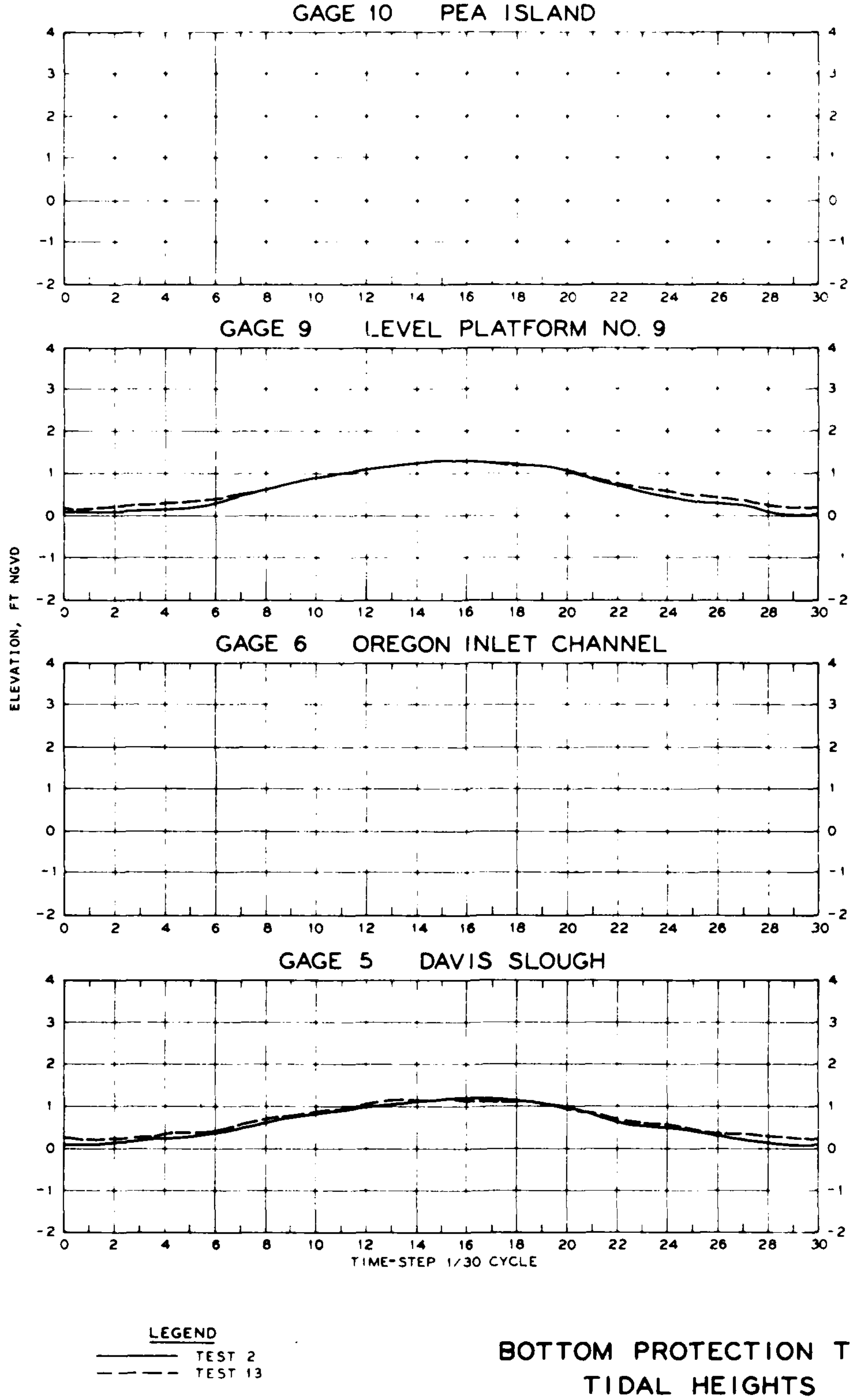
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 1 VS 12
STATIONS 175 AND 181



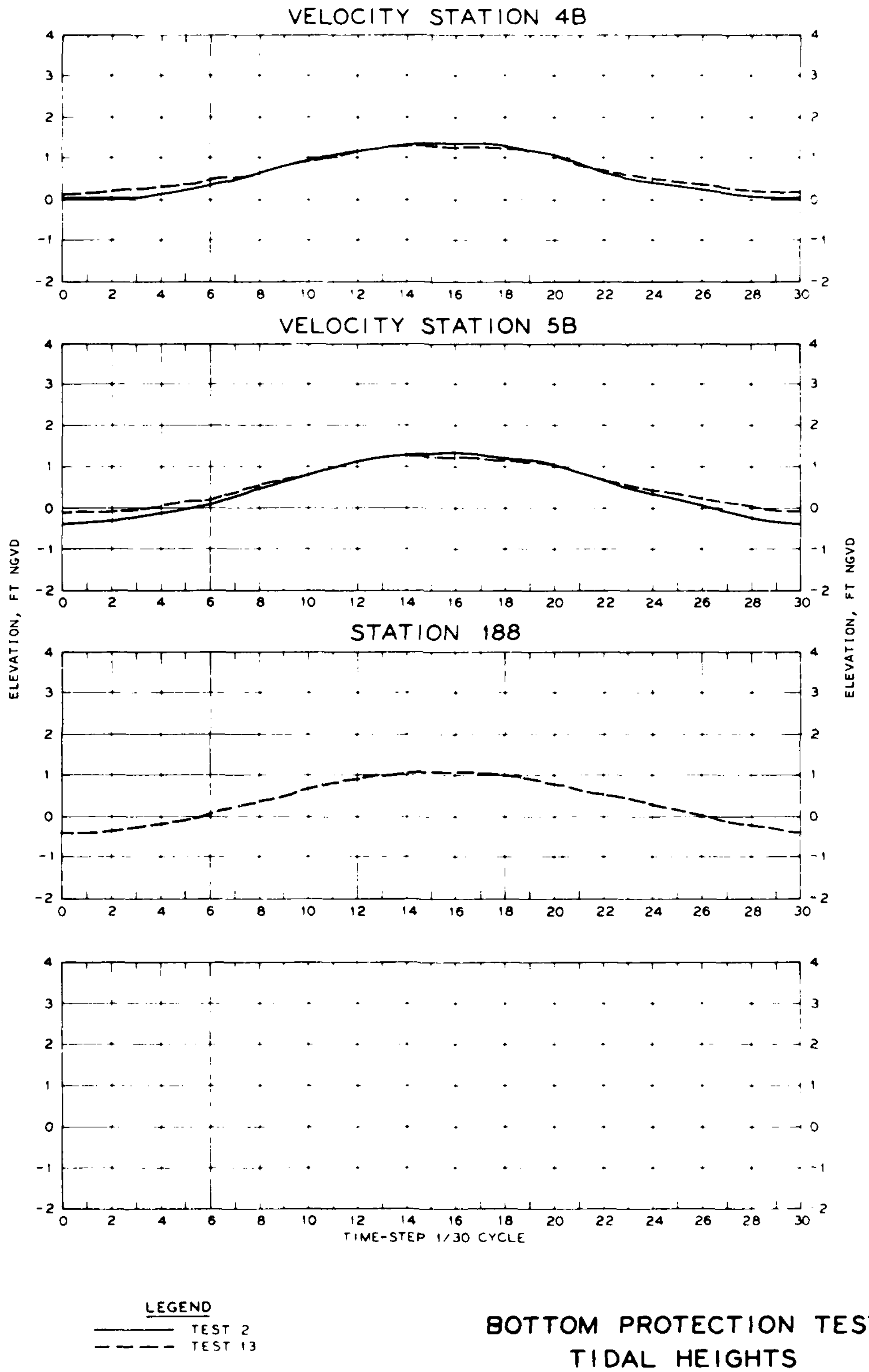
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 1 VS 12
STATIONS 188 AND 194



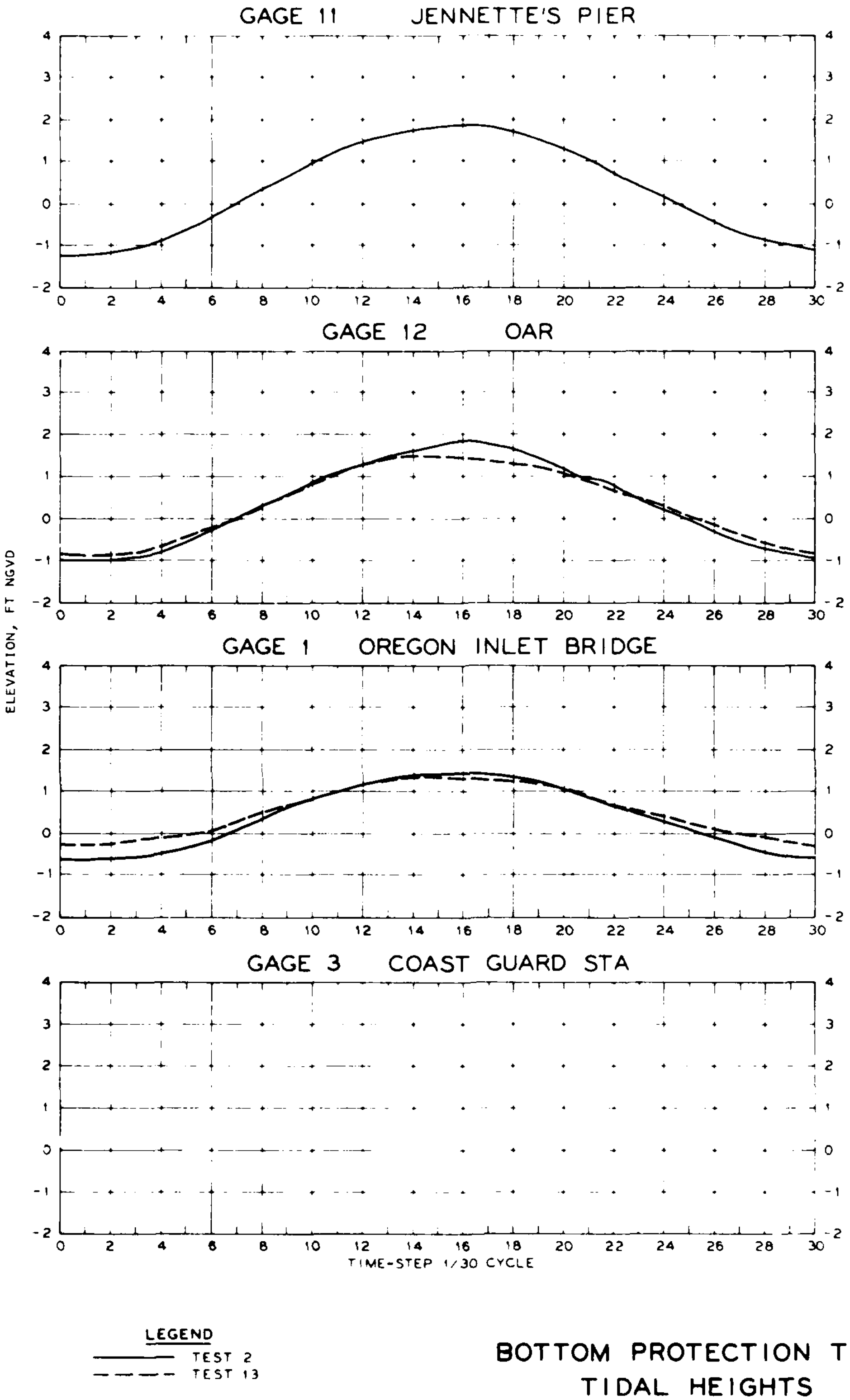
BOTTOM PROTECTION TEST
TIDAL HEIGHTS
TEST 2 VS 13
GAGES 7, 2, AND 8



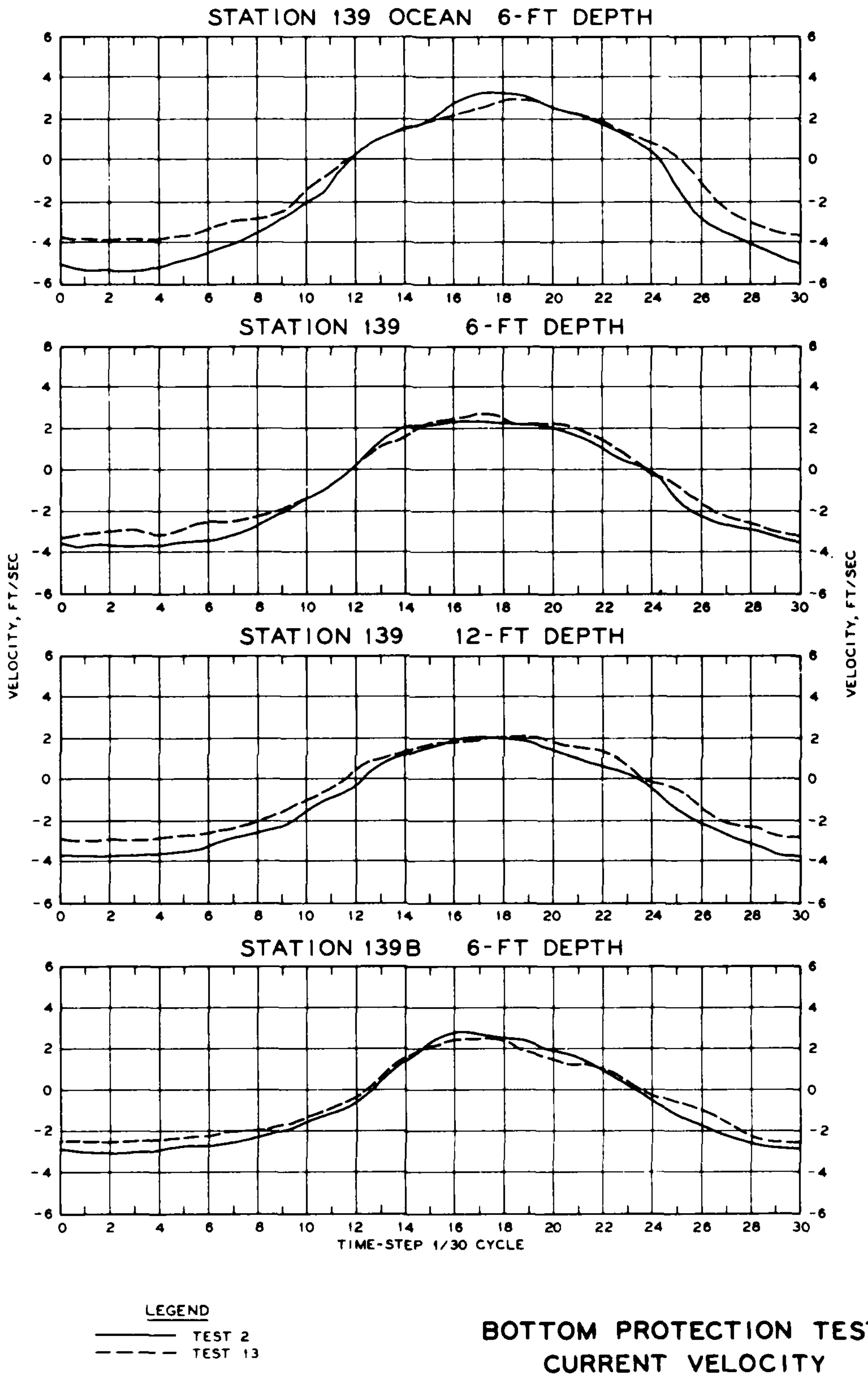
BOTTOM PROTECTION TEST
TIDAL HEIGHTS
TEST 2 VS 13
GAGES 10, 9, 6, AND 5



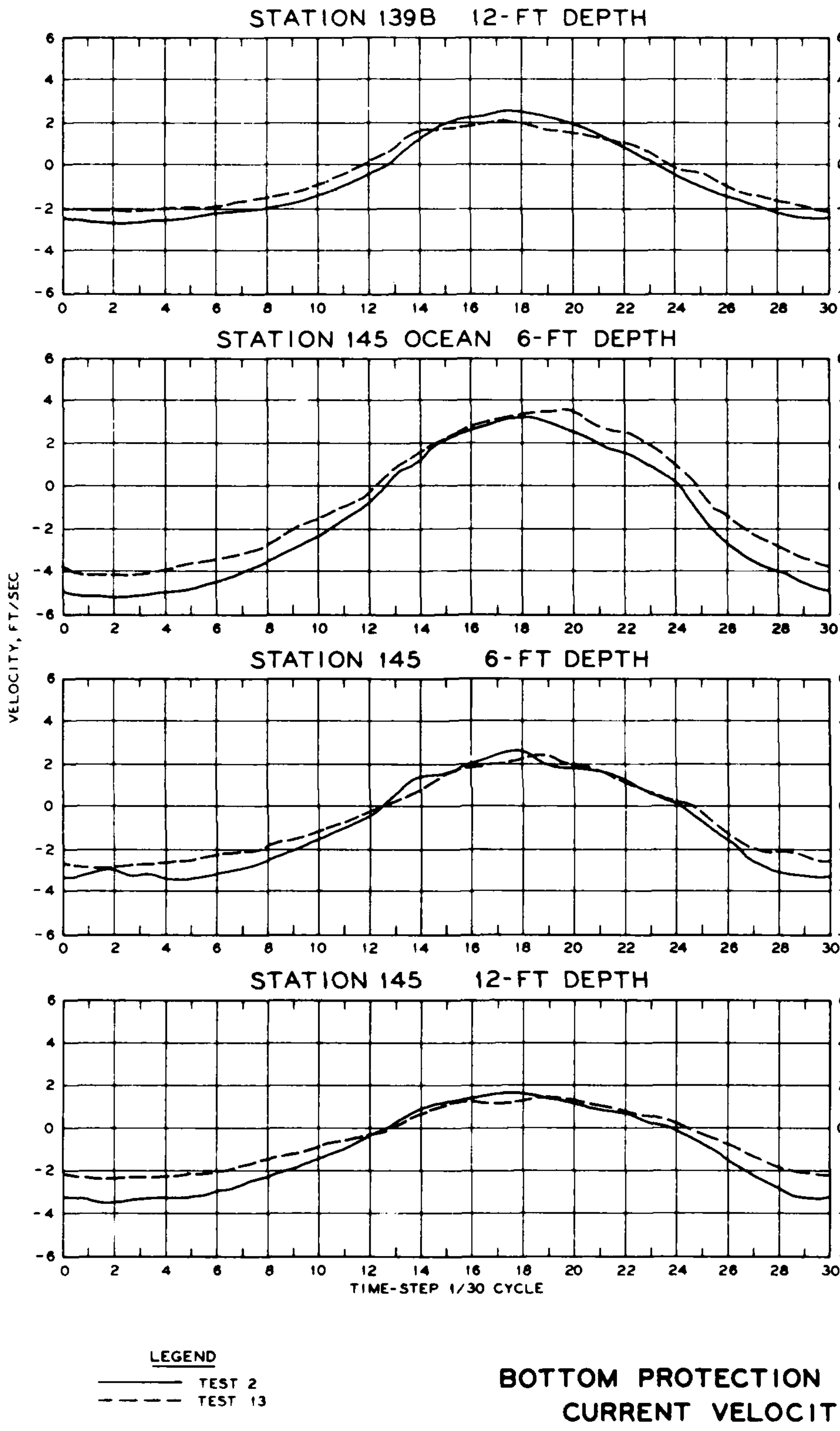
BOTTOM PROTECTION TEST
TIDAL HEIGHTS
TEST 2 VS 13
STATIONS 4B, 5B, AND 188



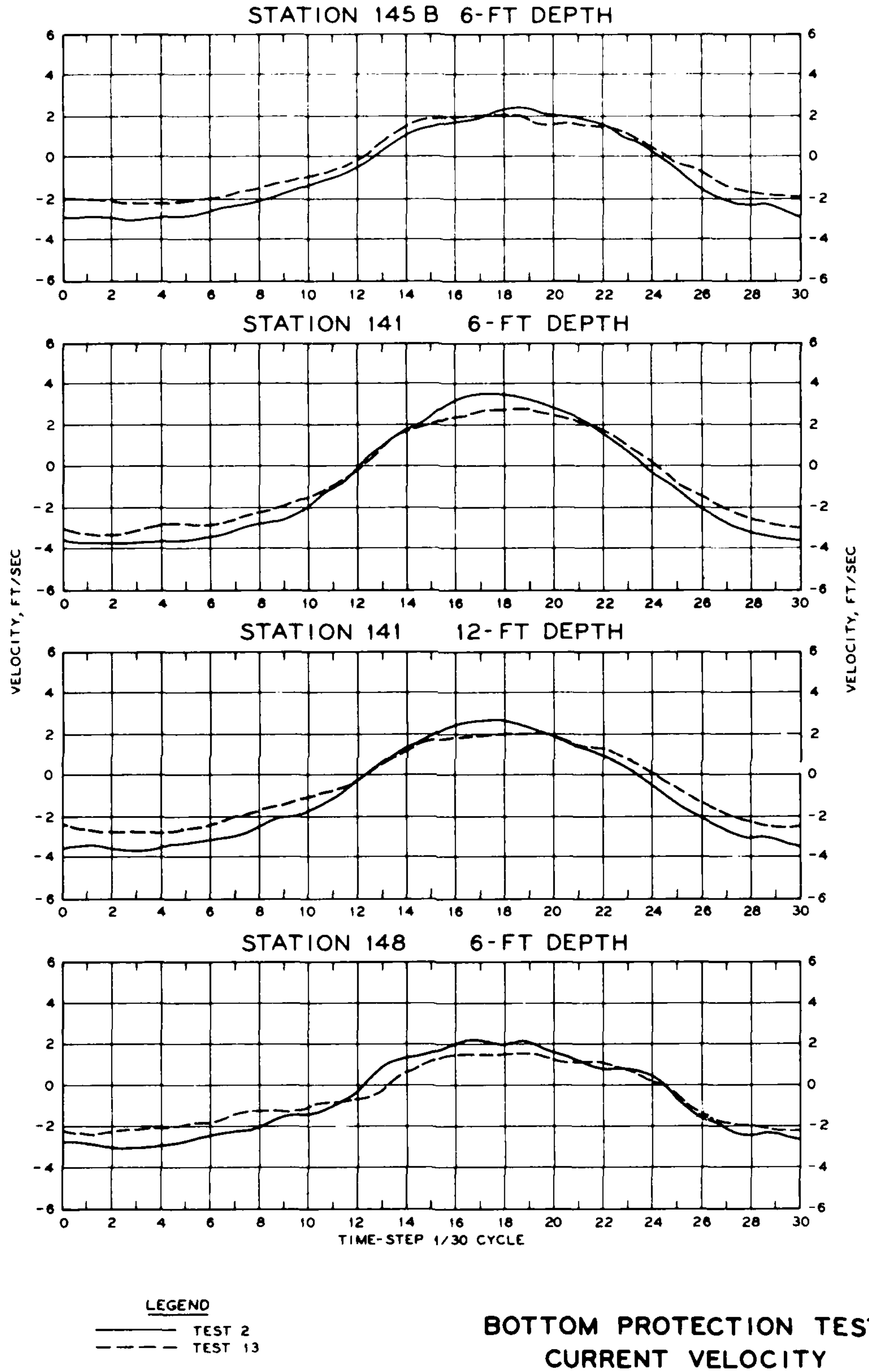
BOTTOM PROTECTION TEST
TIDAL HEIGHTS
TEST 2 VS 13
GAGES 11, 12, 1, AND 3



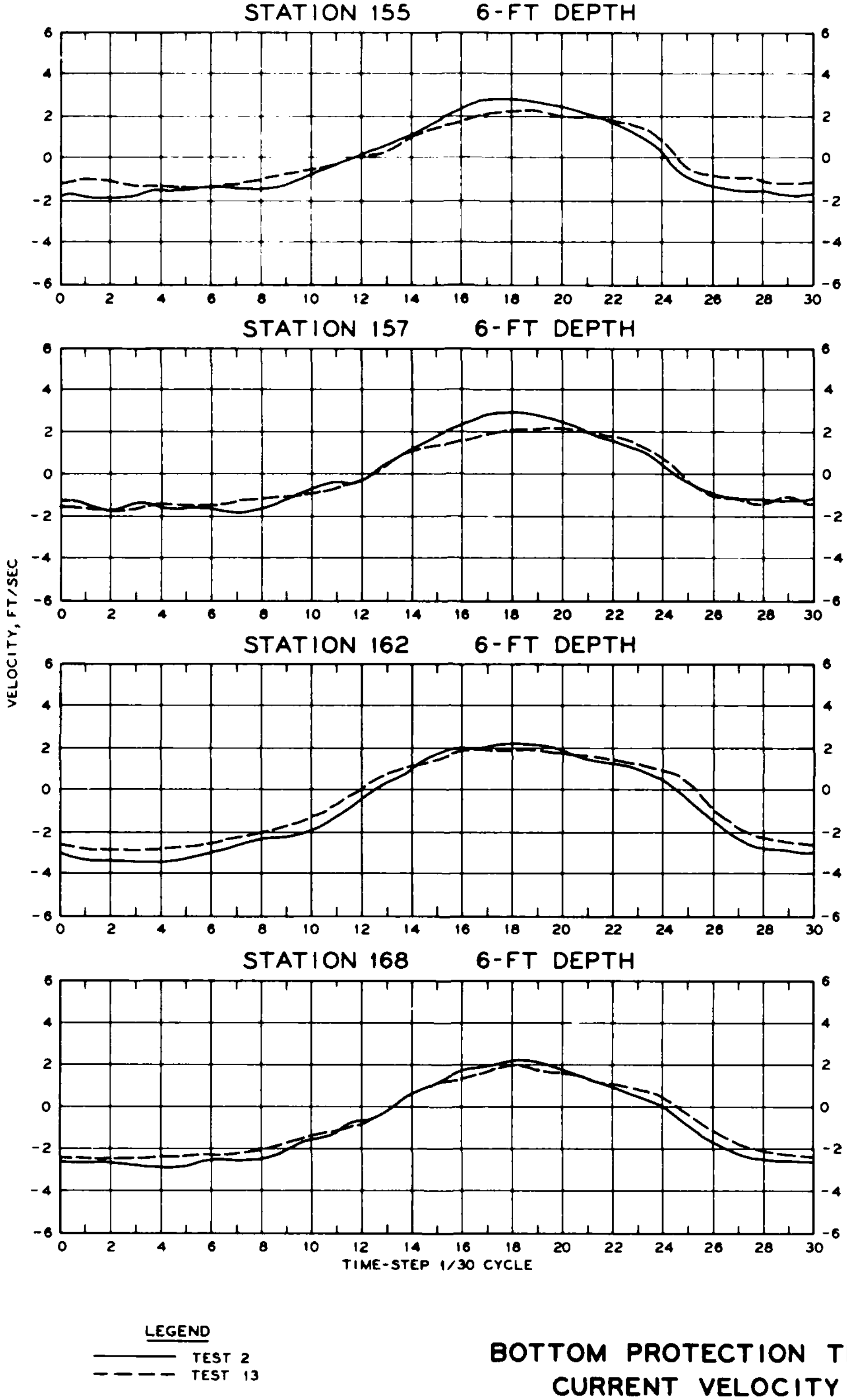
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 2 VS 13
STATION 139



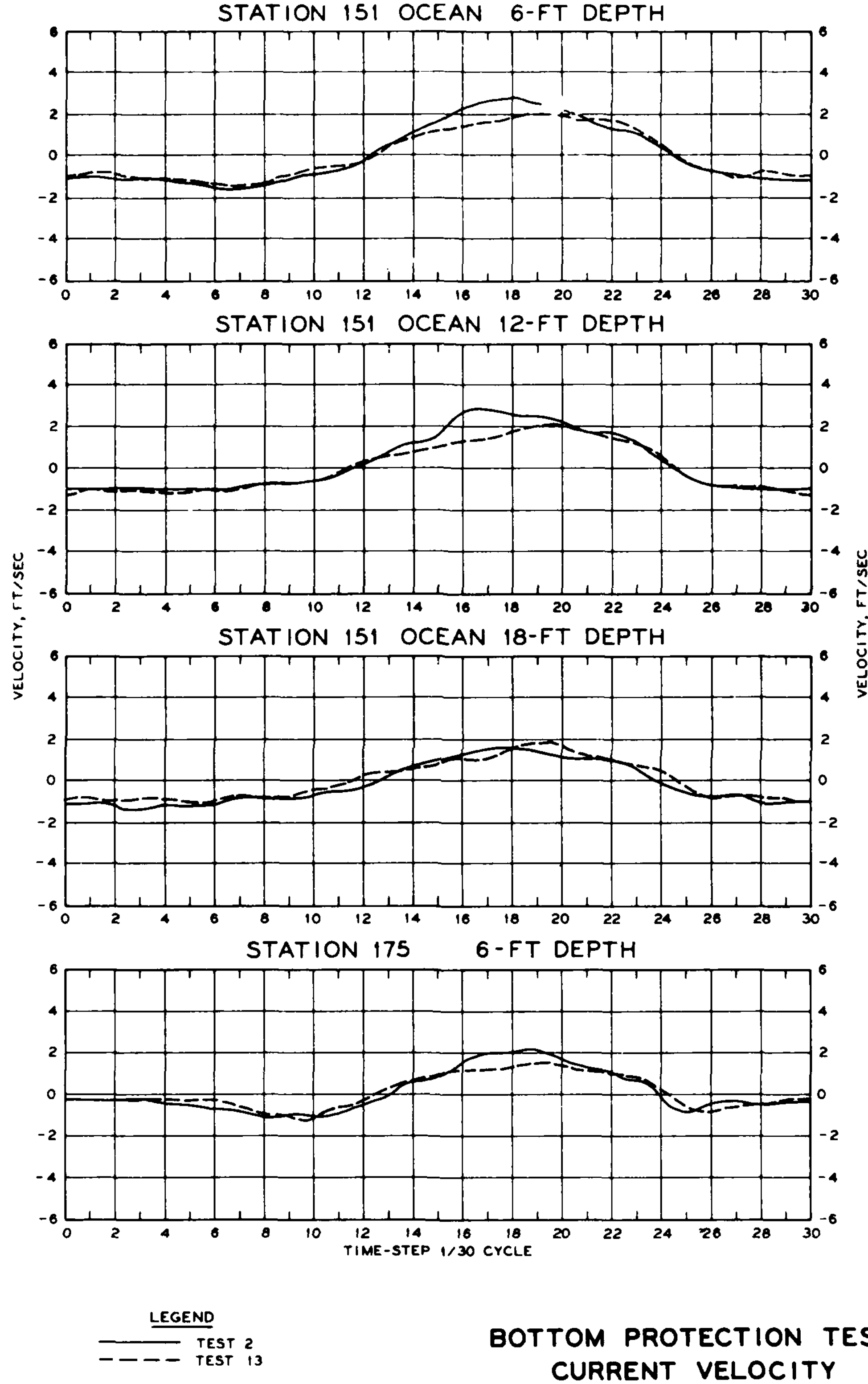
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 2 VS 13
STATIONS 139 AND 145



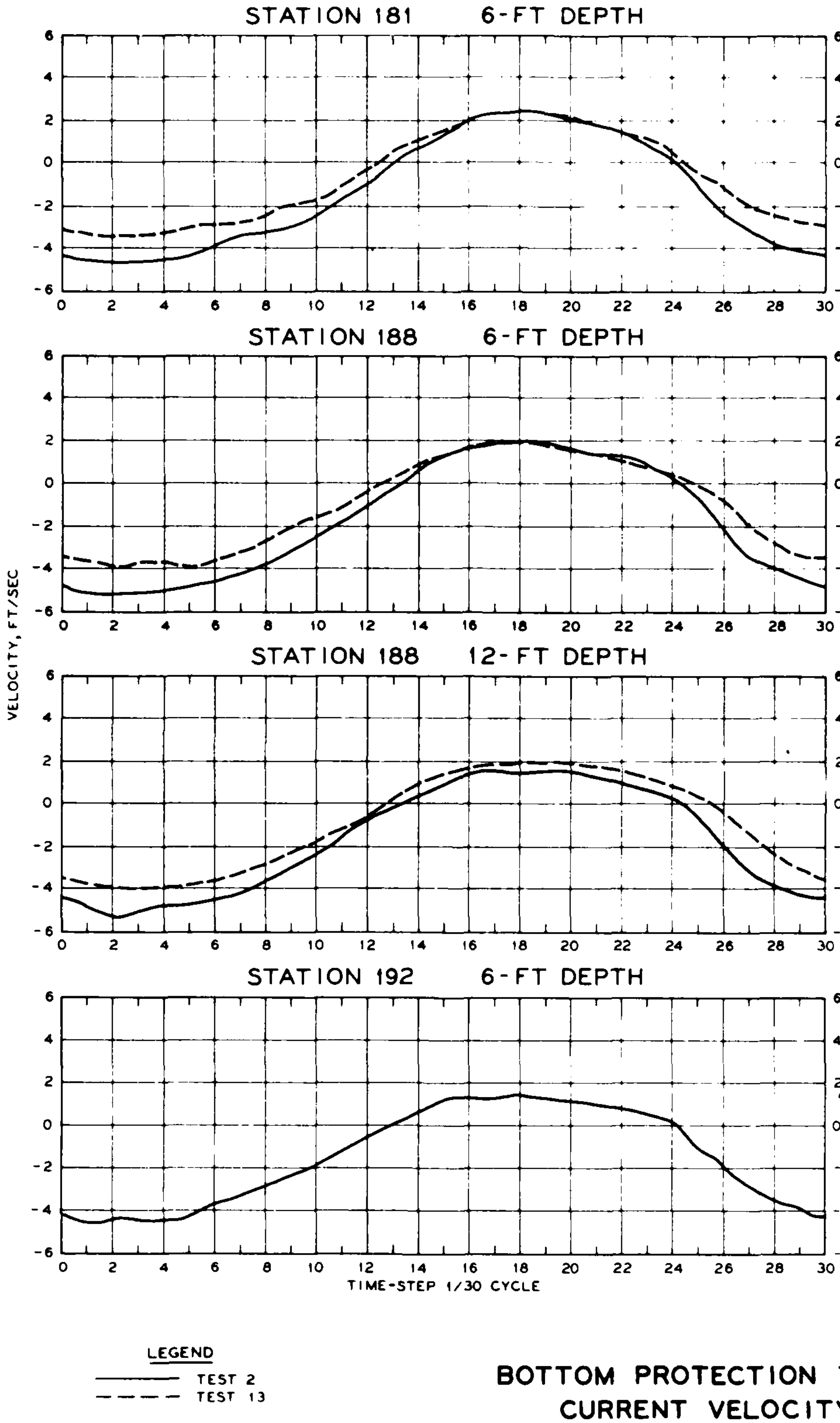
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 2 VS 13
STATIONS 145B, 141, AND 148



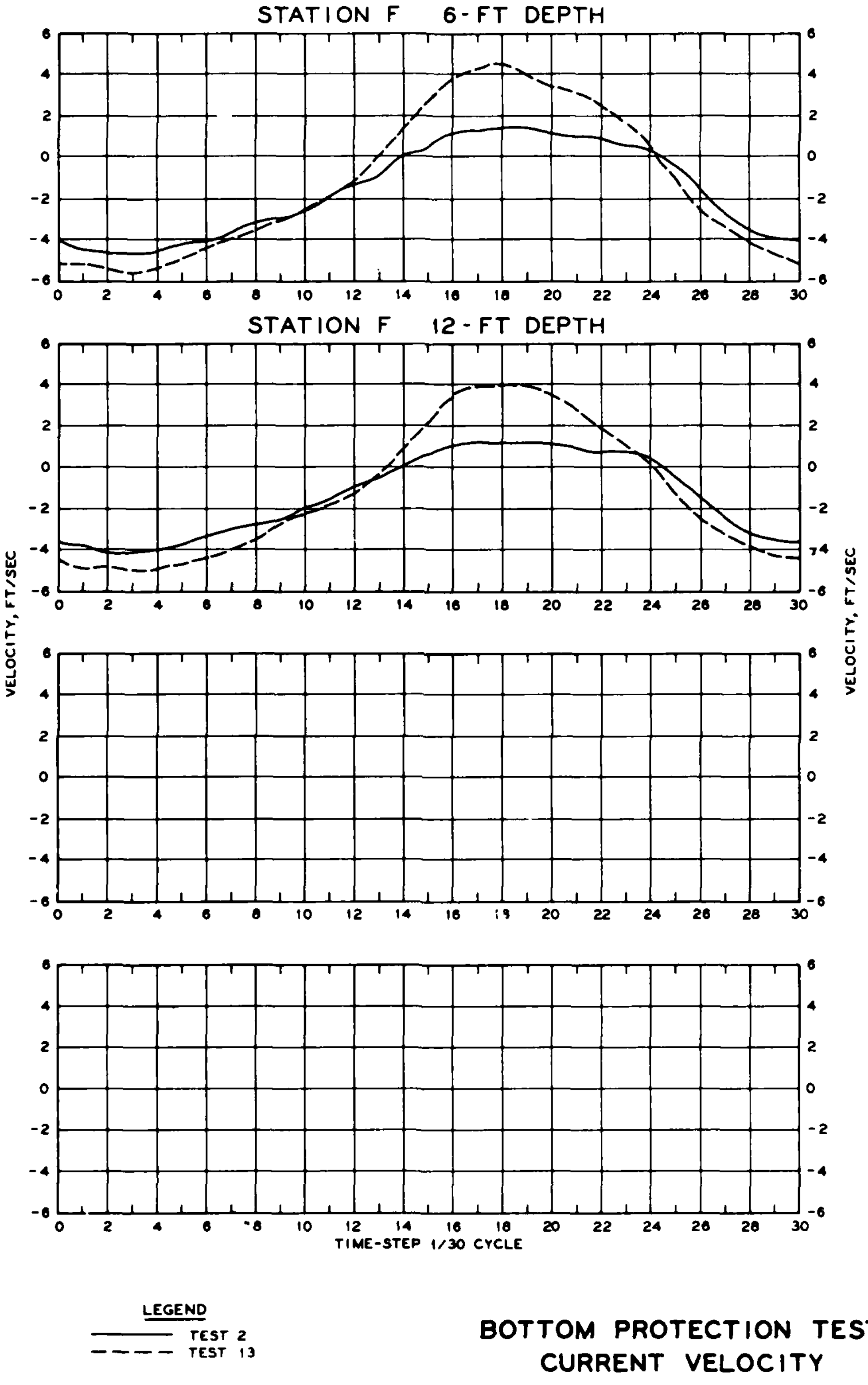
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 2 VS 13
STATIONS 155, 157, 162, AND 168



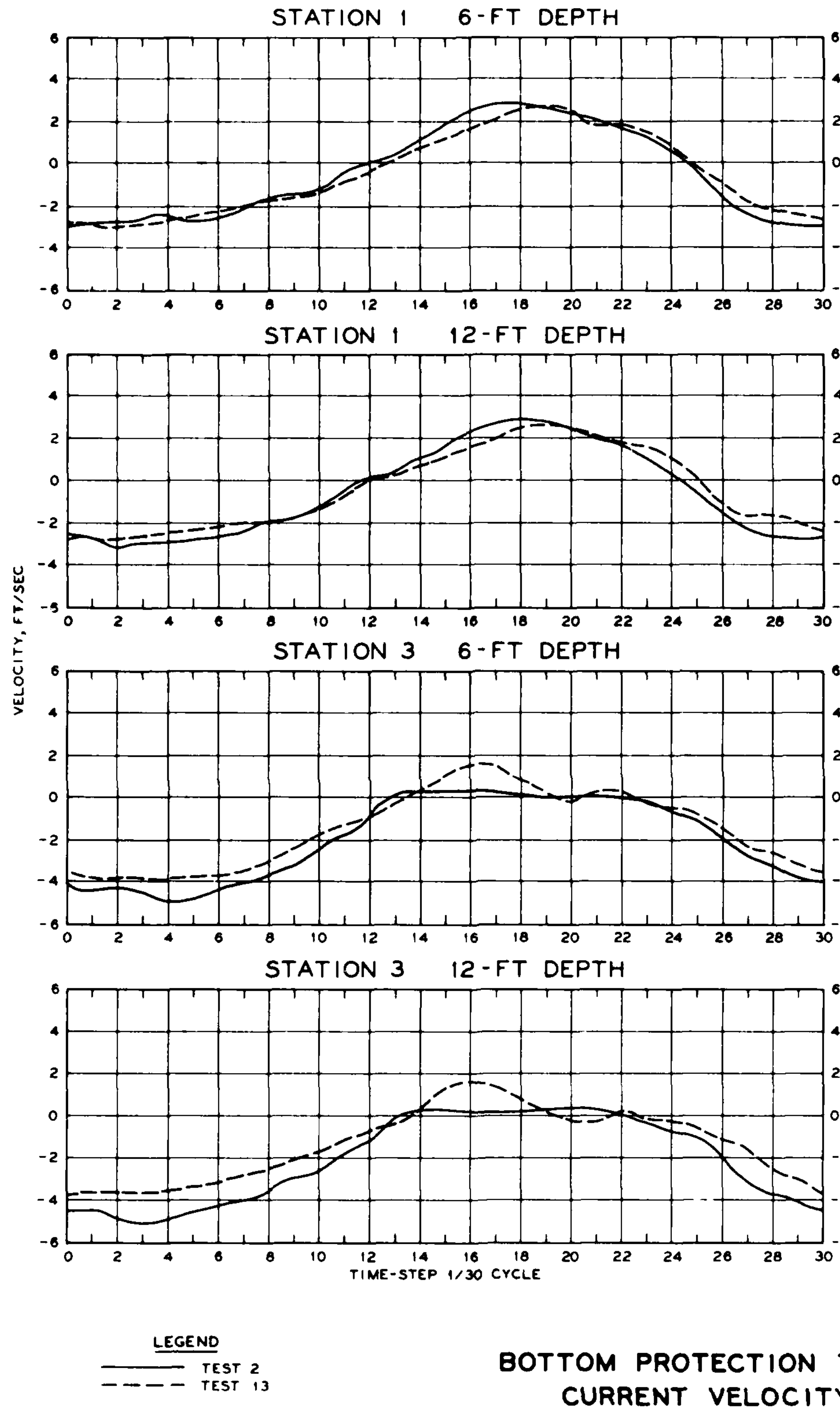
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 2 VS 13
STATIONS 151 AND 175



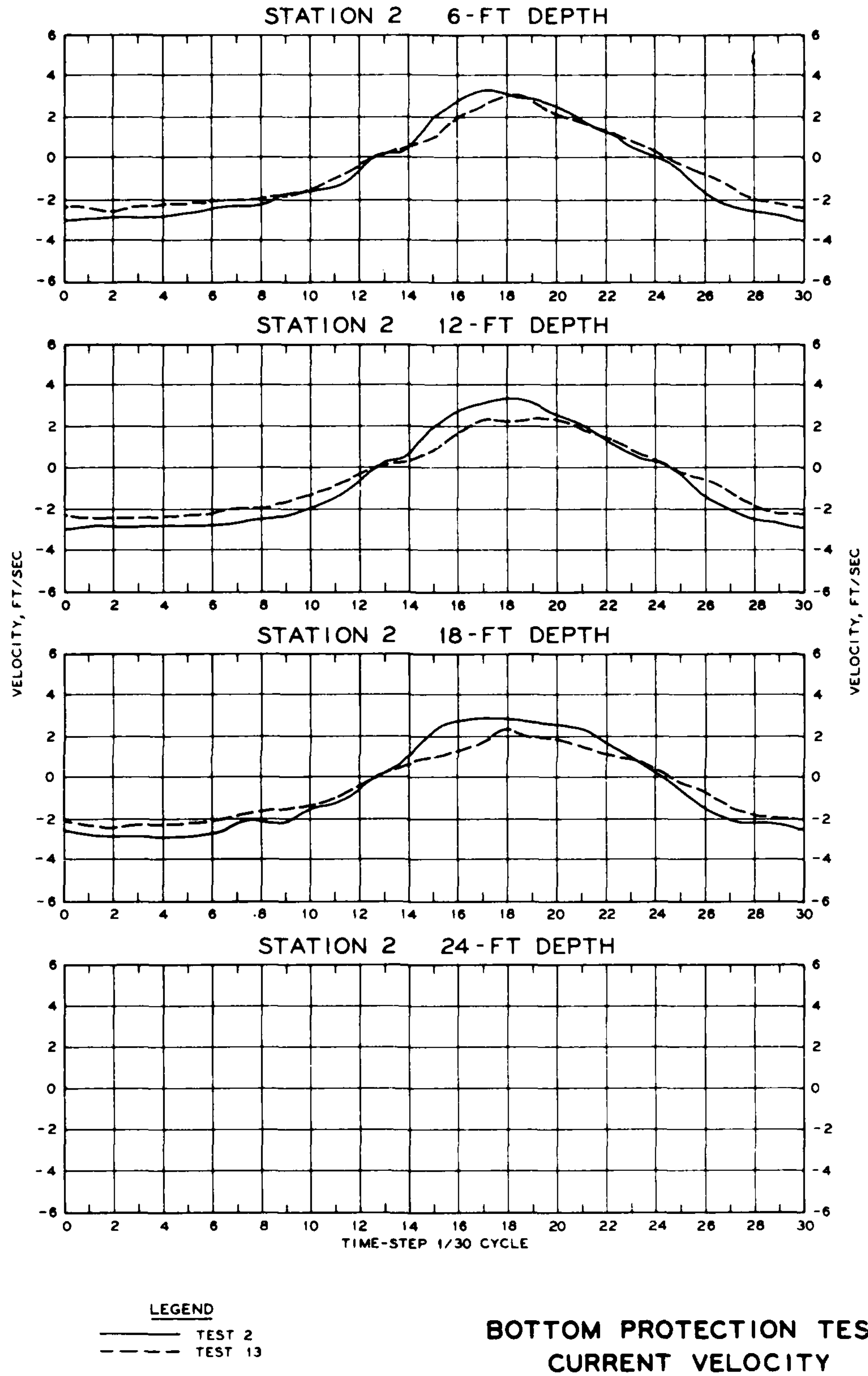
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 2 VS 13
STATIONS 181, 188, AND 192



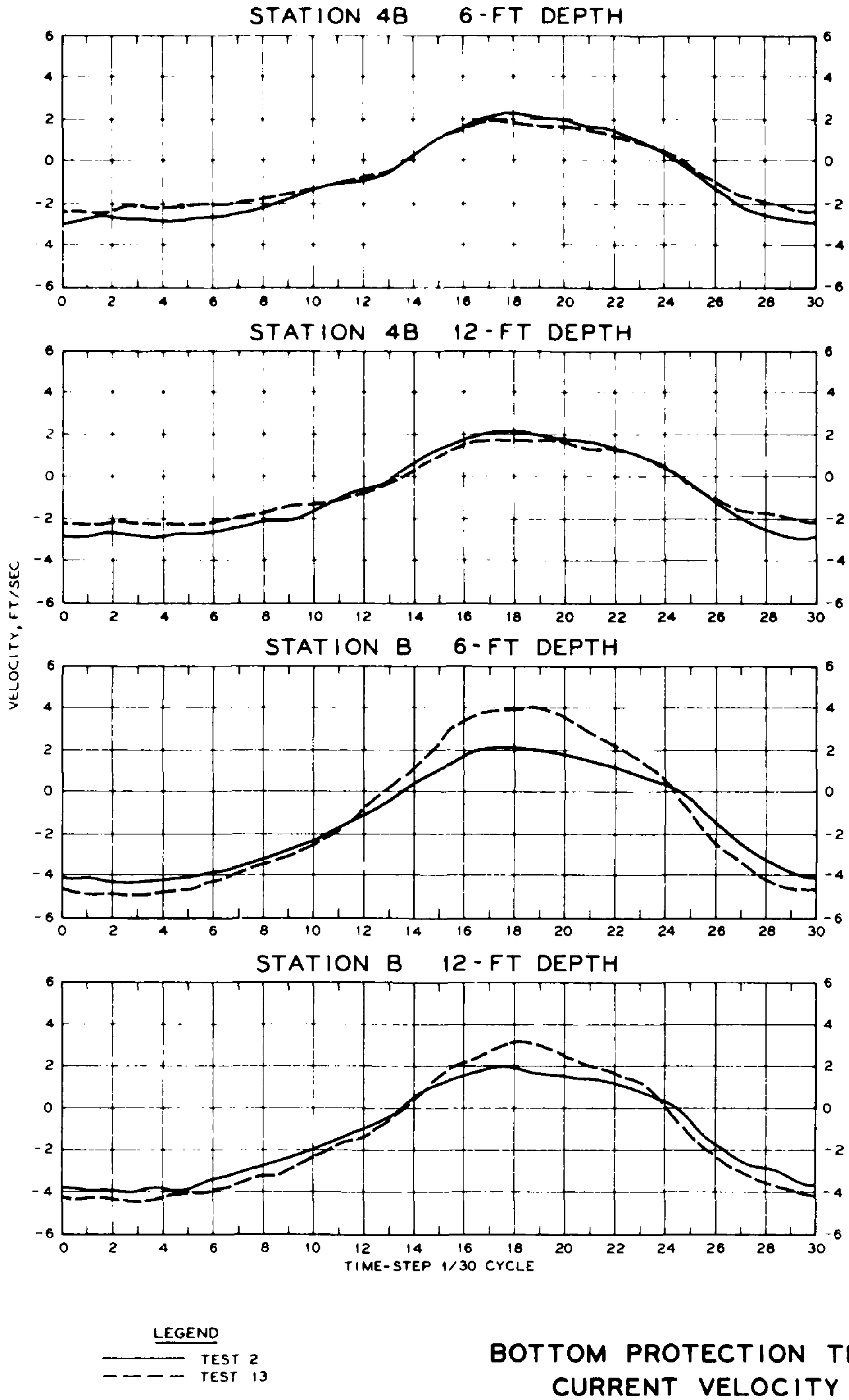
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 2 VS 13
STATION F



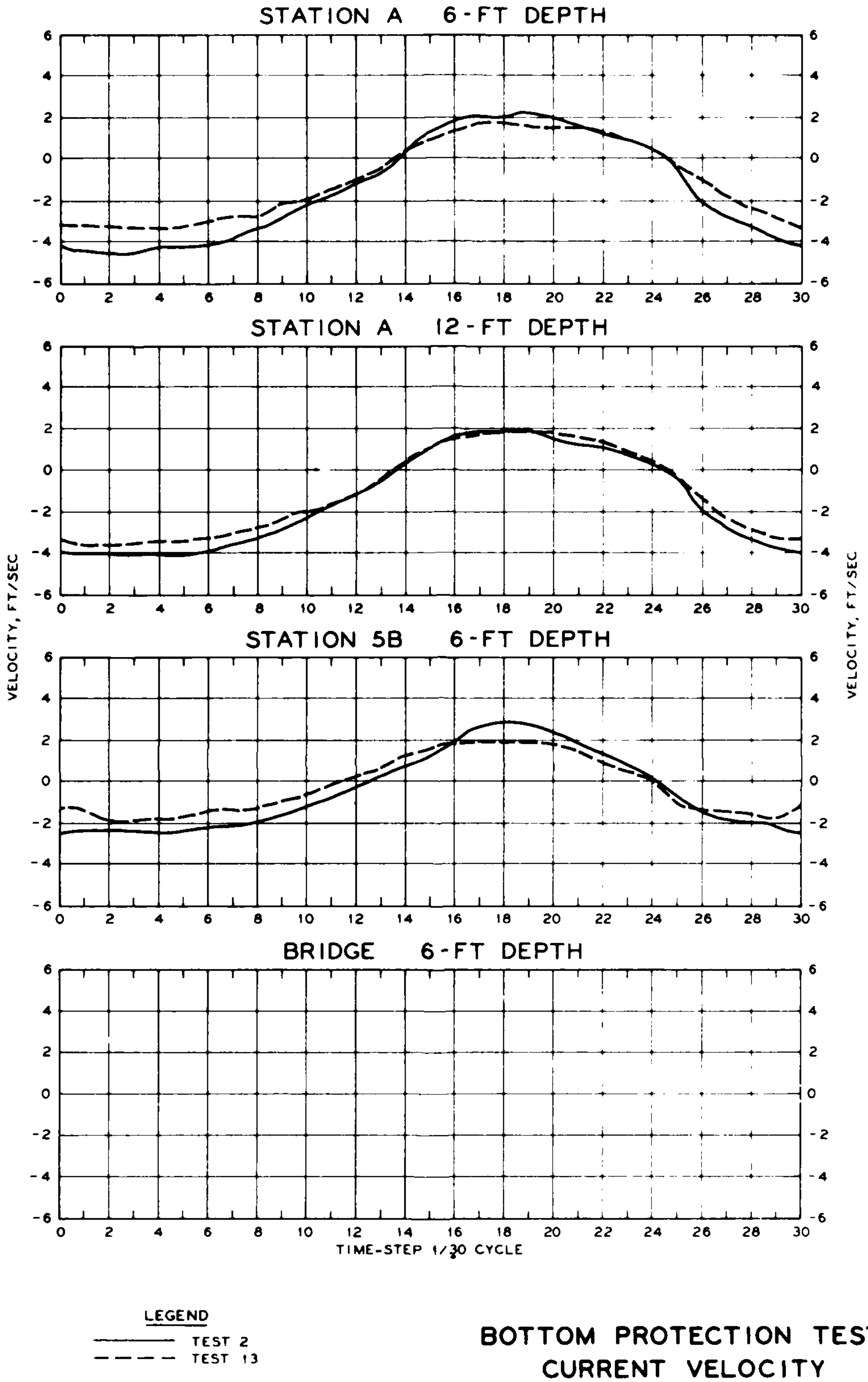
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 2 VS 13
STATIONS 1 AND 3



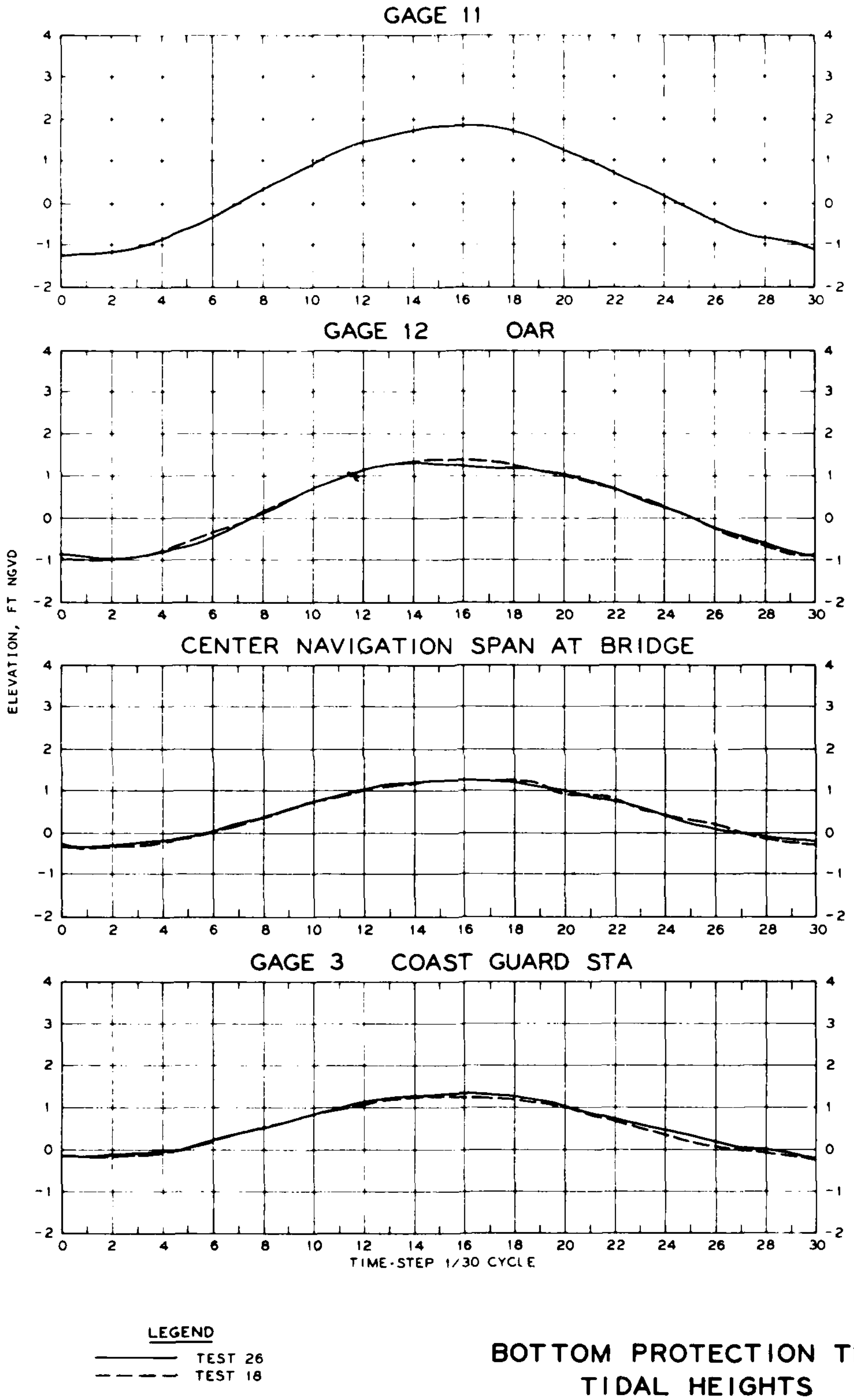
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 2 VS 13
STATION 2



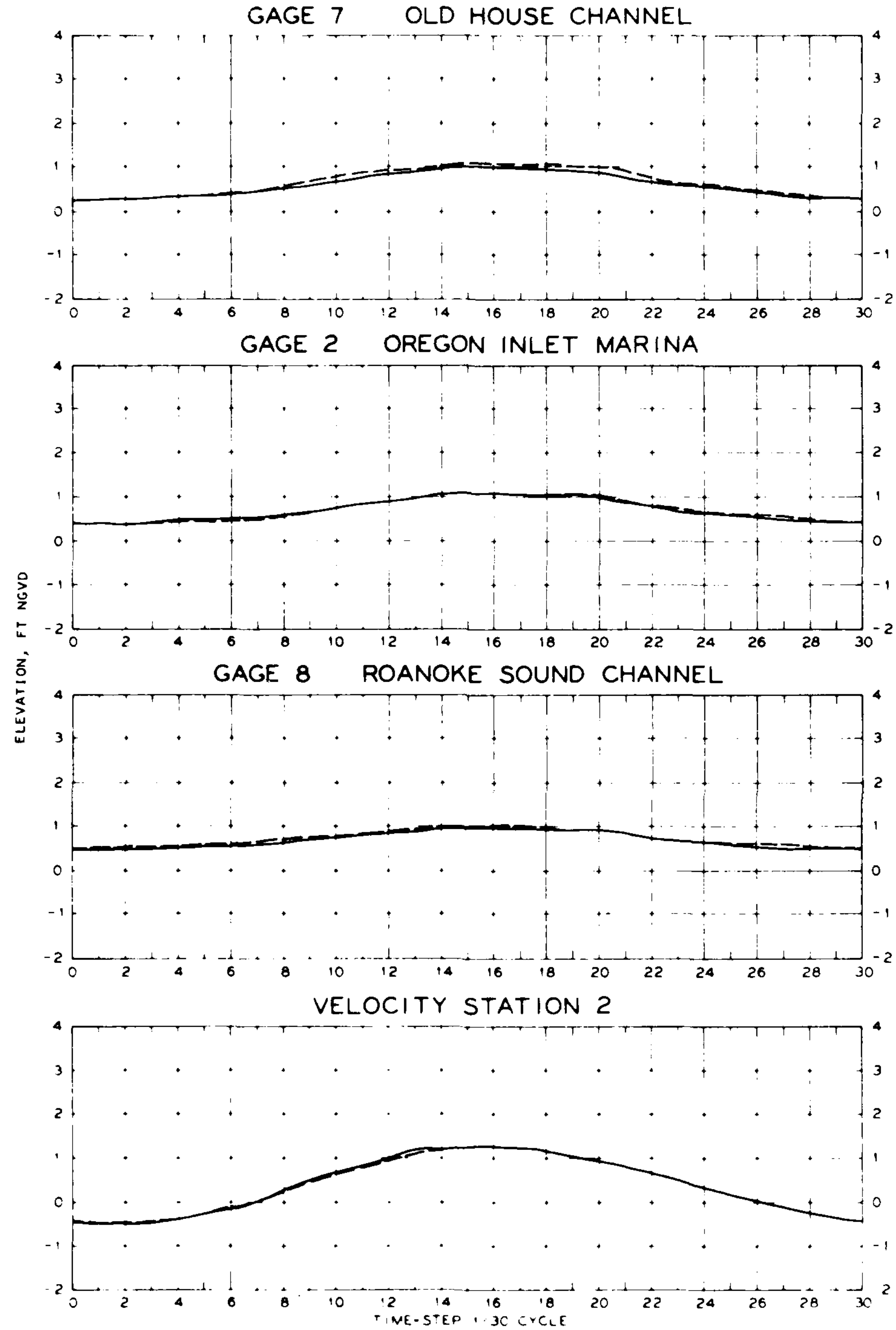
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 2 VS 13
STATIONS 4B AND B



BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 2 VS 13
STATIONS A, 5B, AND BRIDGE



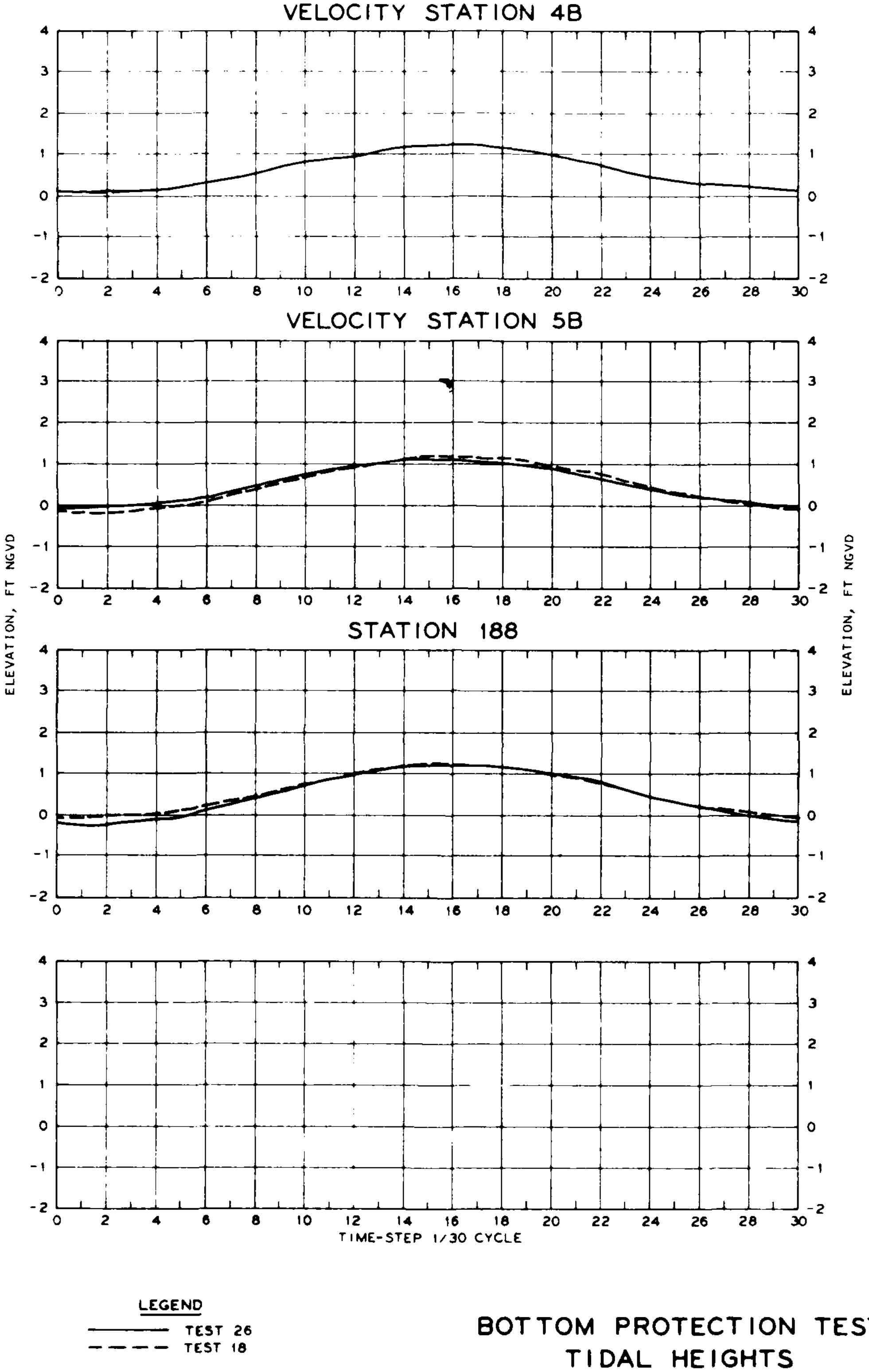
BOTTOM PROTECTION TEST
TIDAL HEIGHTS
TEST 18 VS 26
GAGES 11, 12, BRIDGE, AND 3



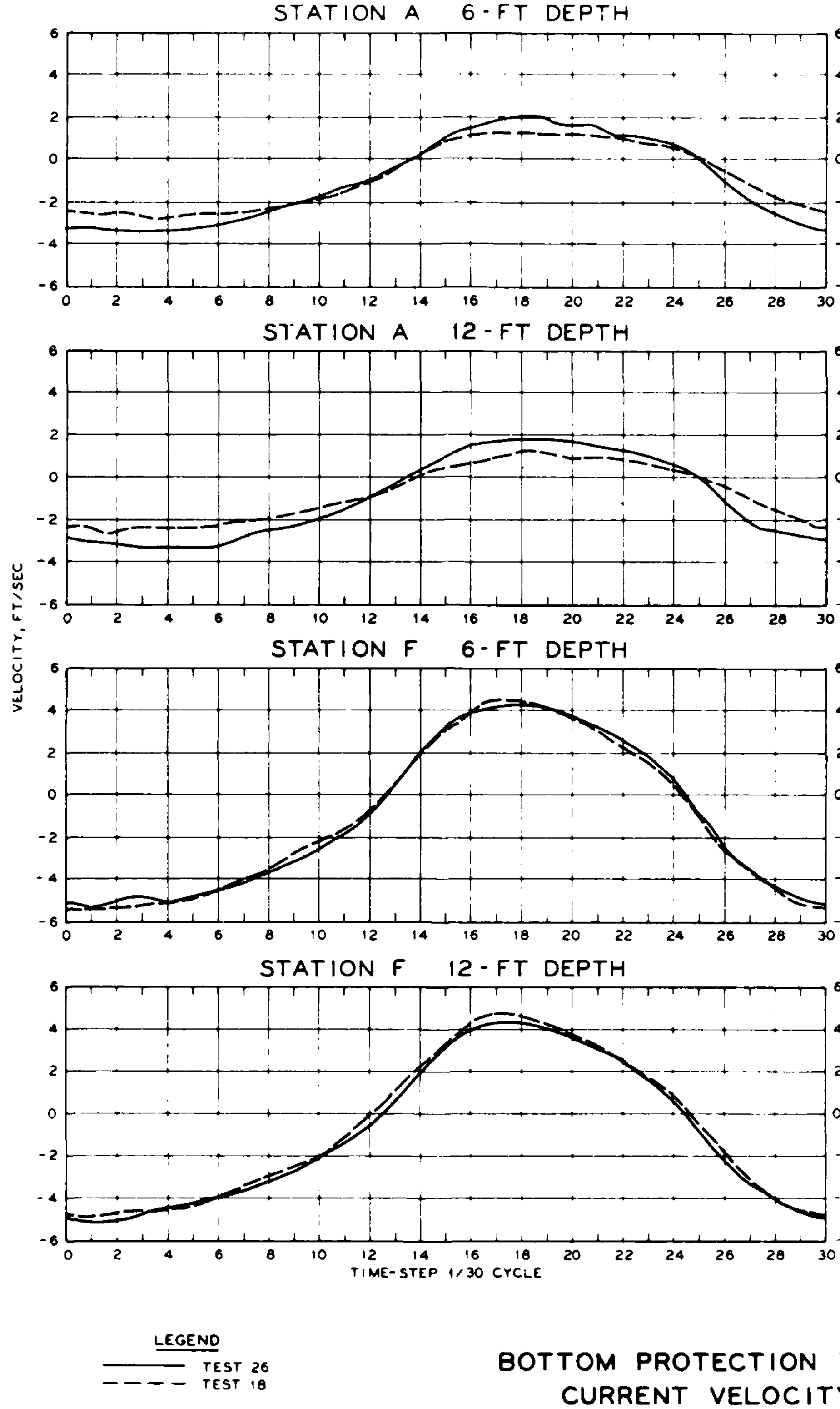
LEGEND

——— TEST 26
– – – TEST 18

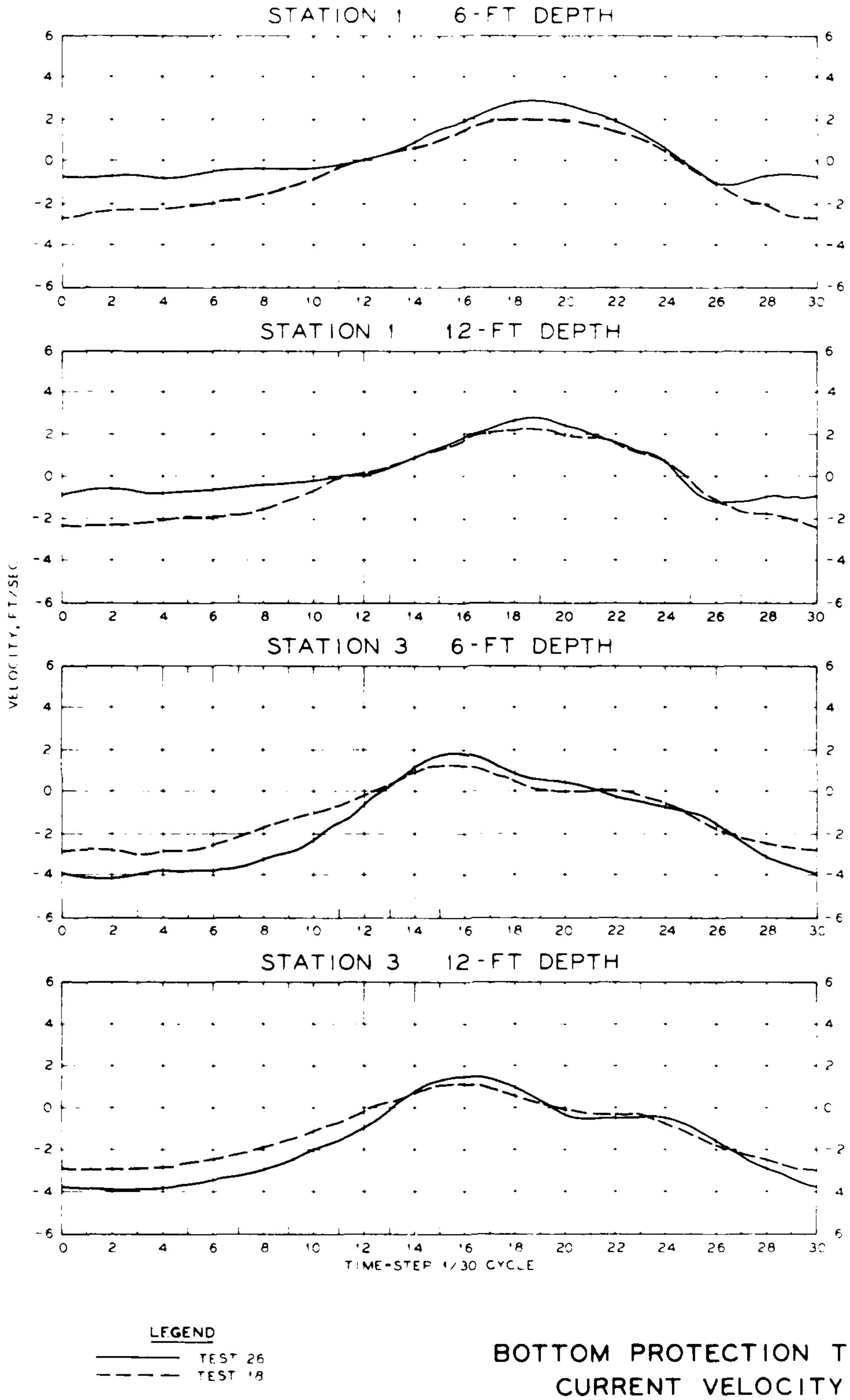
BOTTOM PROTECTION TEST
TIDAL HEIGHTS
TEST 18 VS 26
GAGES 7, 2, AND 8



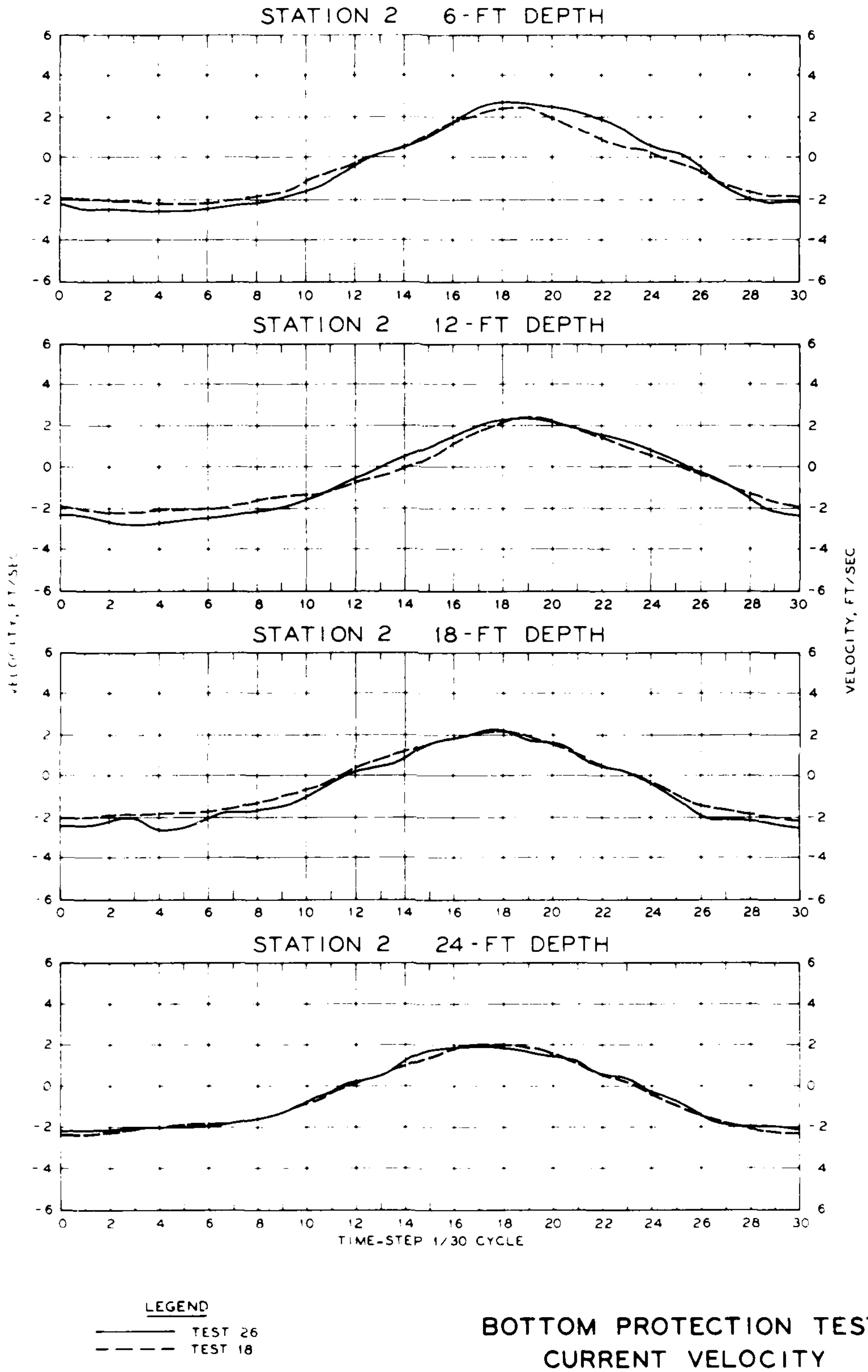
BOTTOM PROTECTION TEST
TIDAL HEIGHTS
TEST 18 VS 26
STATIONS 4B, 5B, AND 188



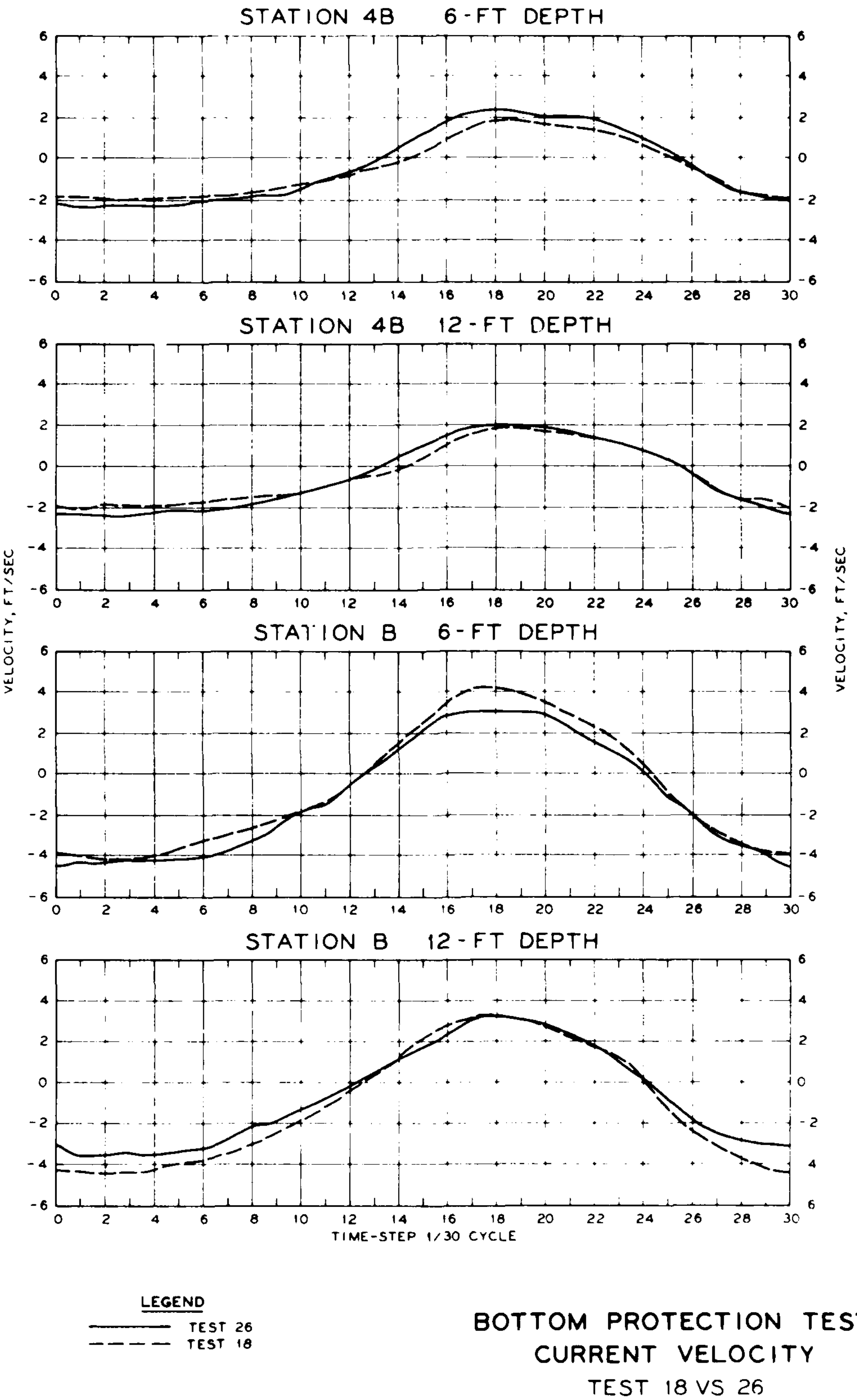
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 18 VS 26
STATIONS A AND F



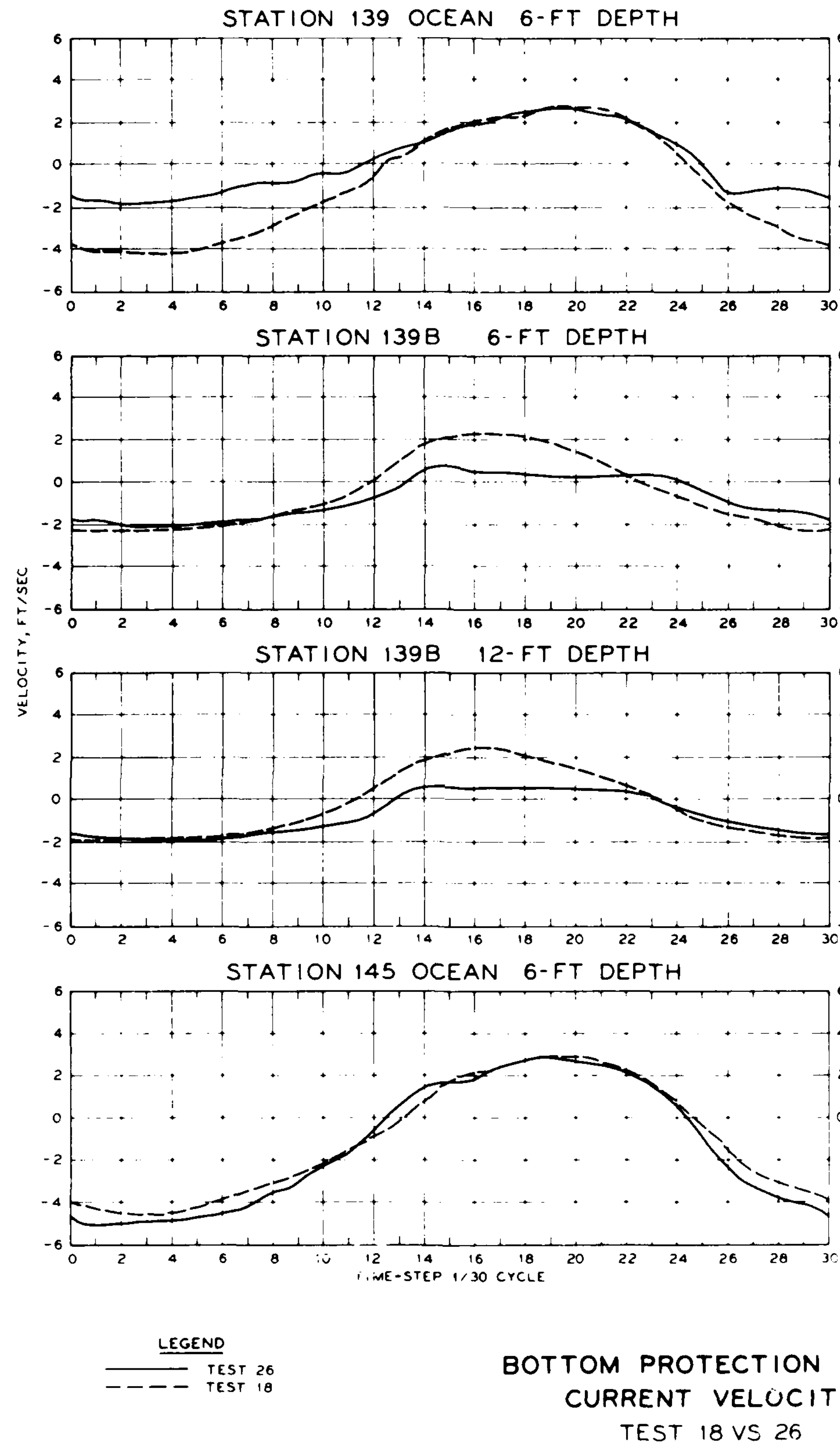
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 18 VS 26
STATIONS 1 AND 3



BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 18 VS 26
STATION 2

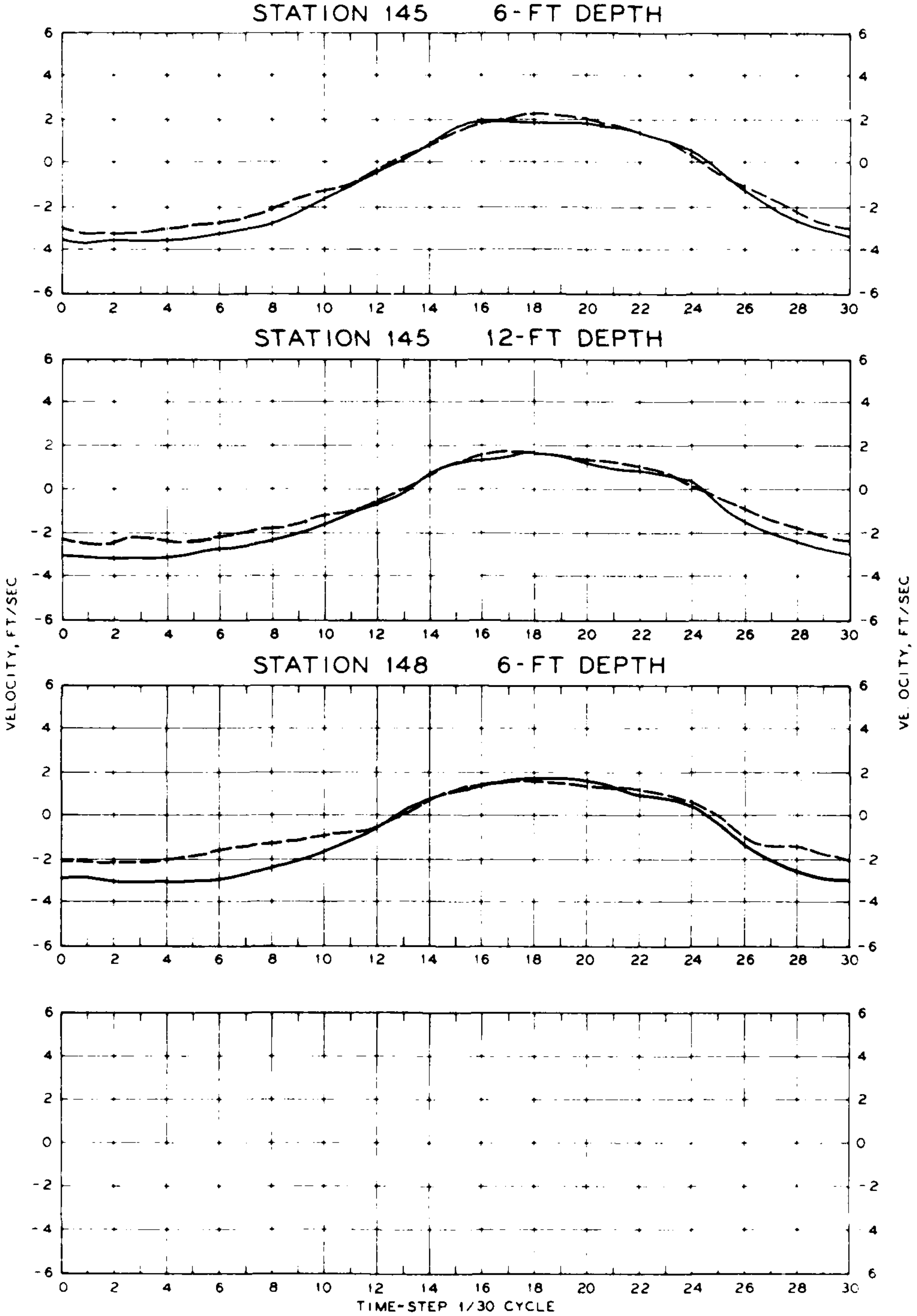


BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 18 VS 26
STATIONS 4B AND B



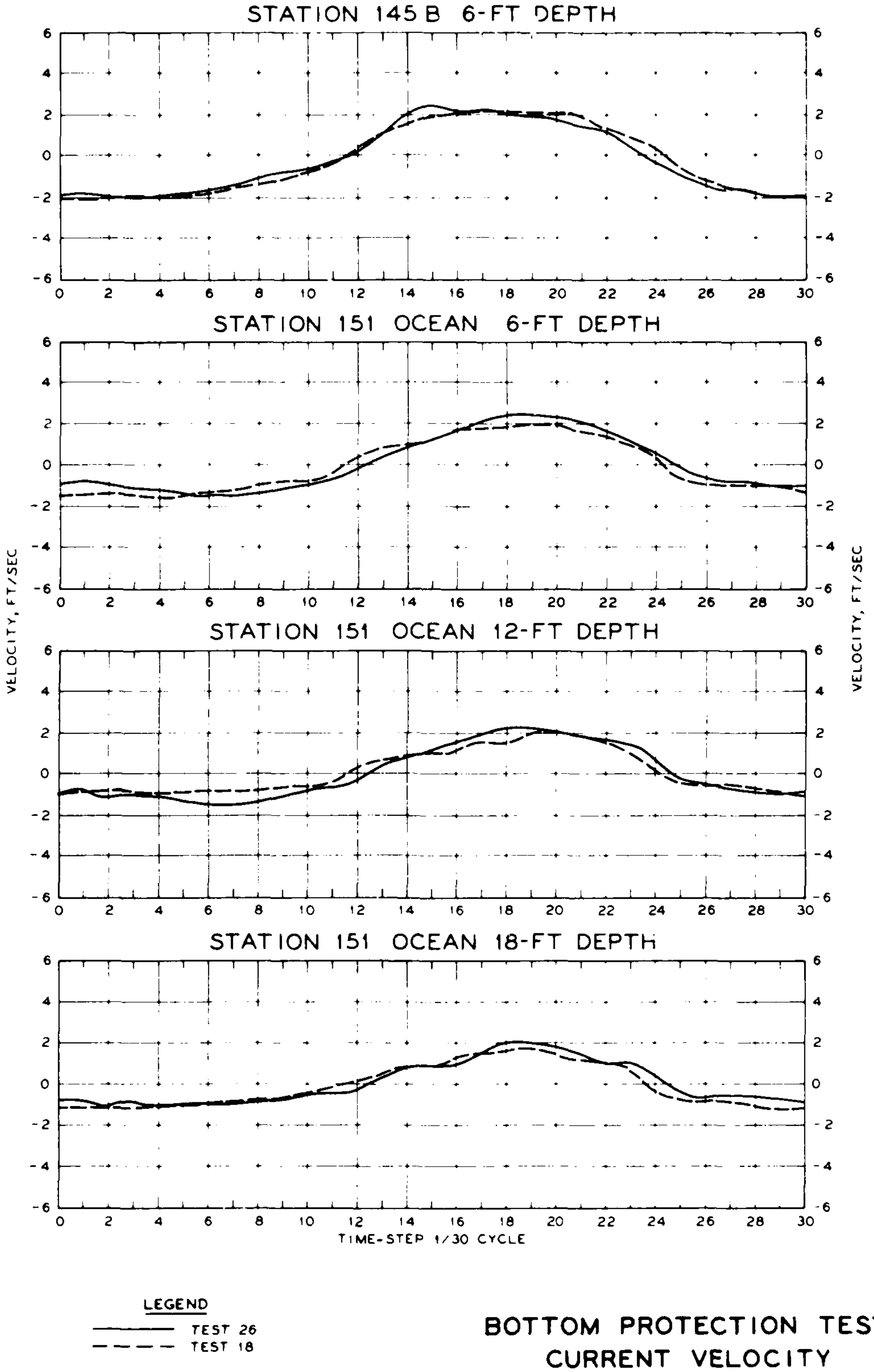
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 18 VS 26
STATIONS 139 AND 145

PLATE 218

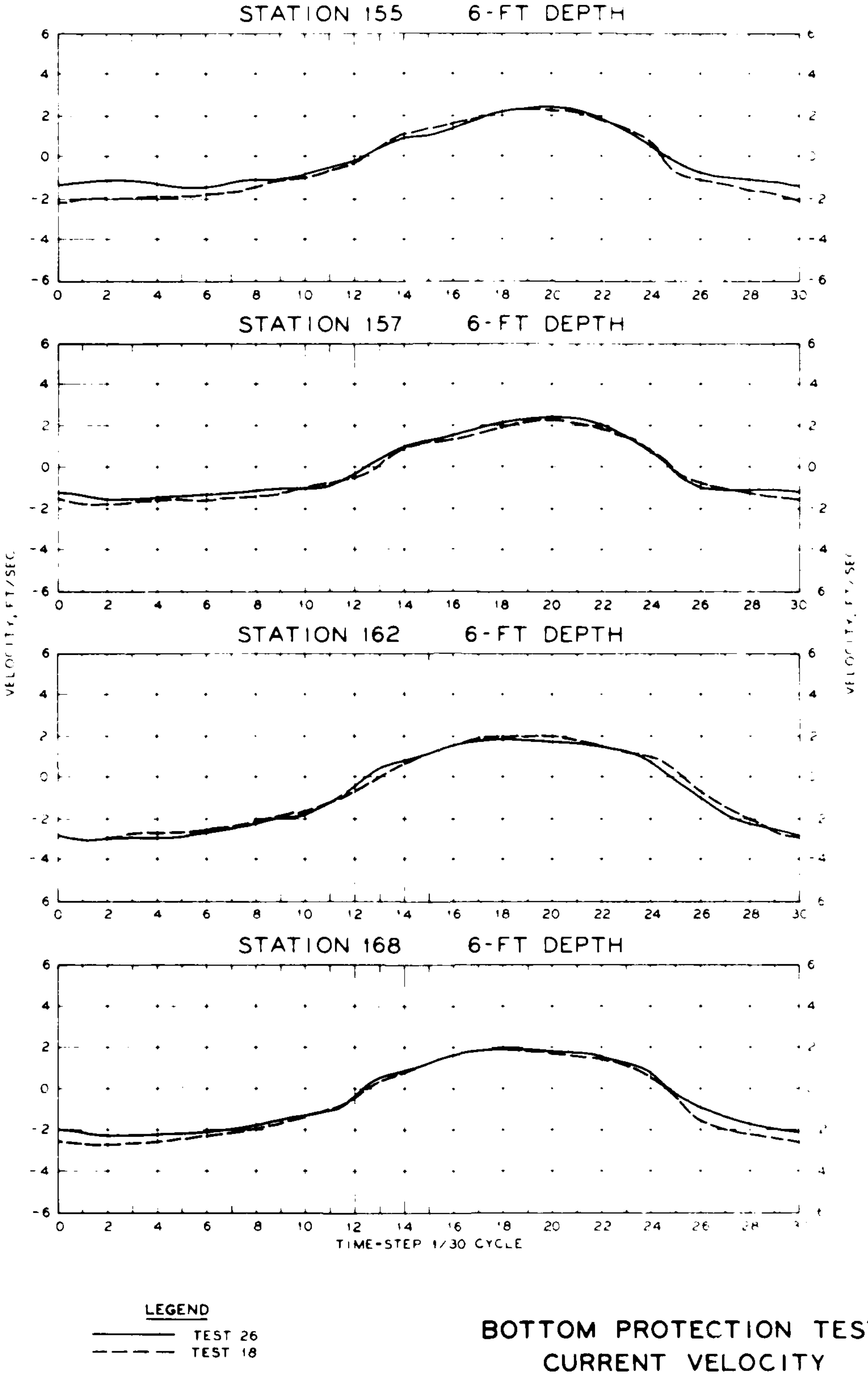


LEGEND
——— TEST 26
– – – TEST 18

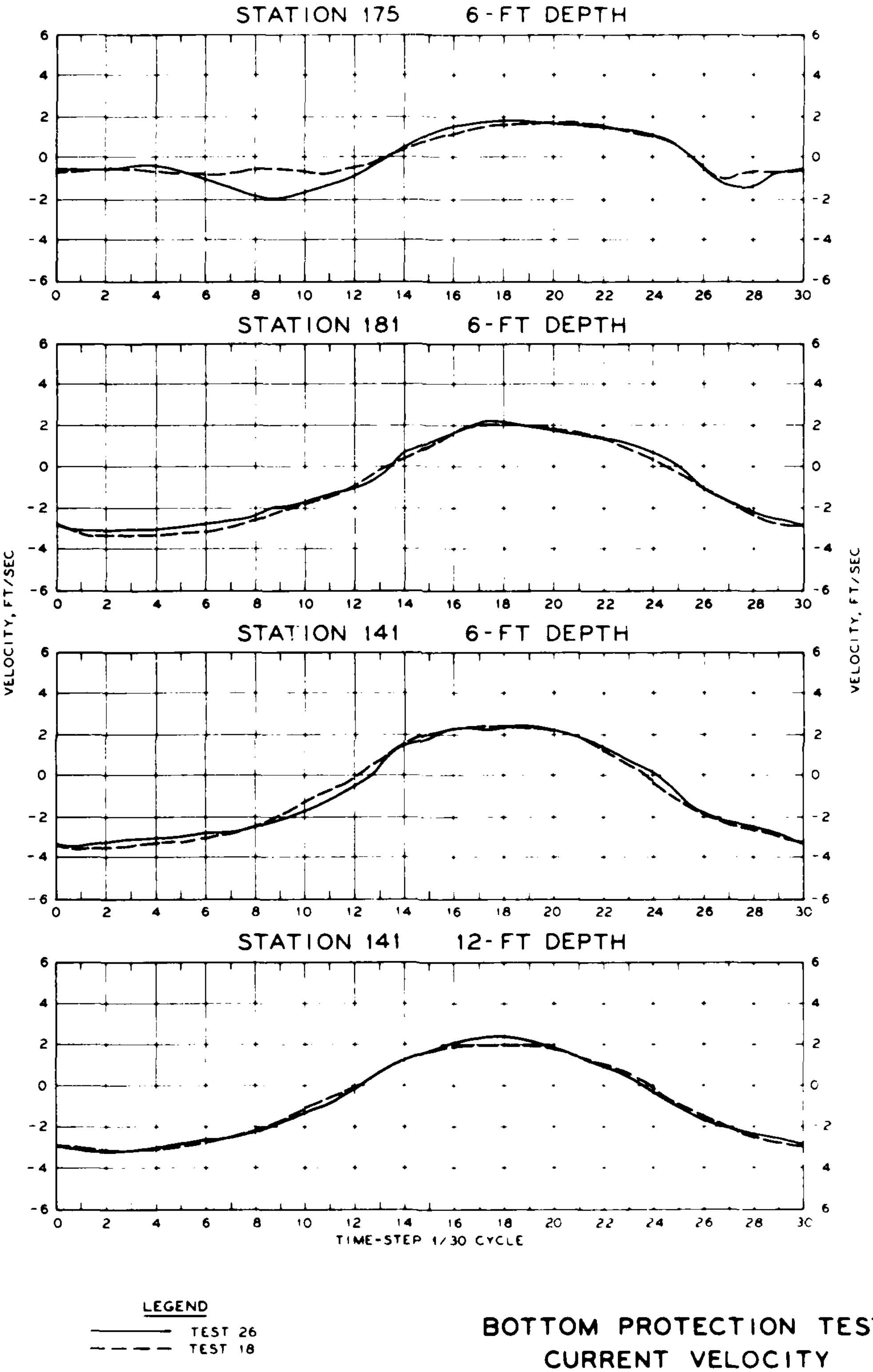
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 18 VS 26
STATIONS 145 AND 148



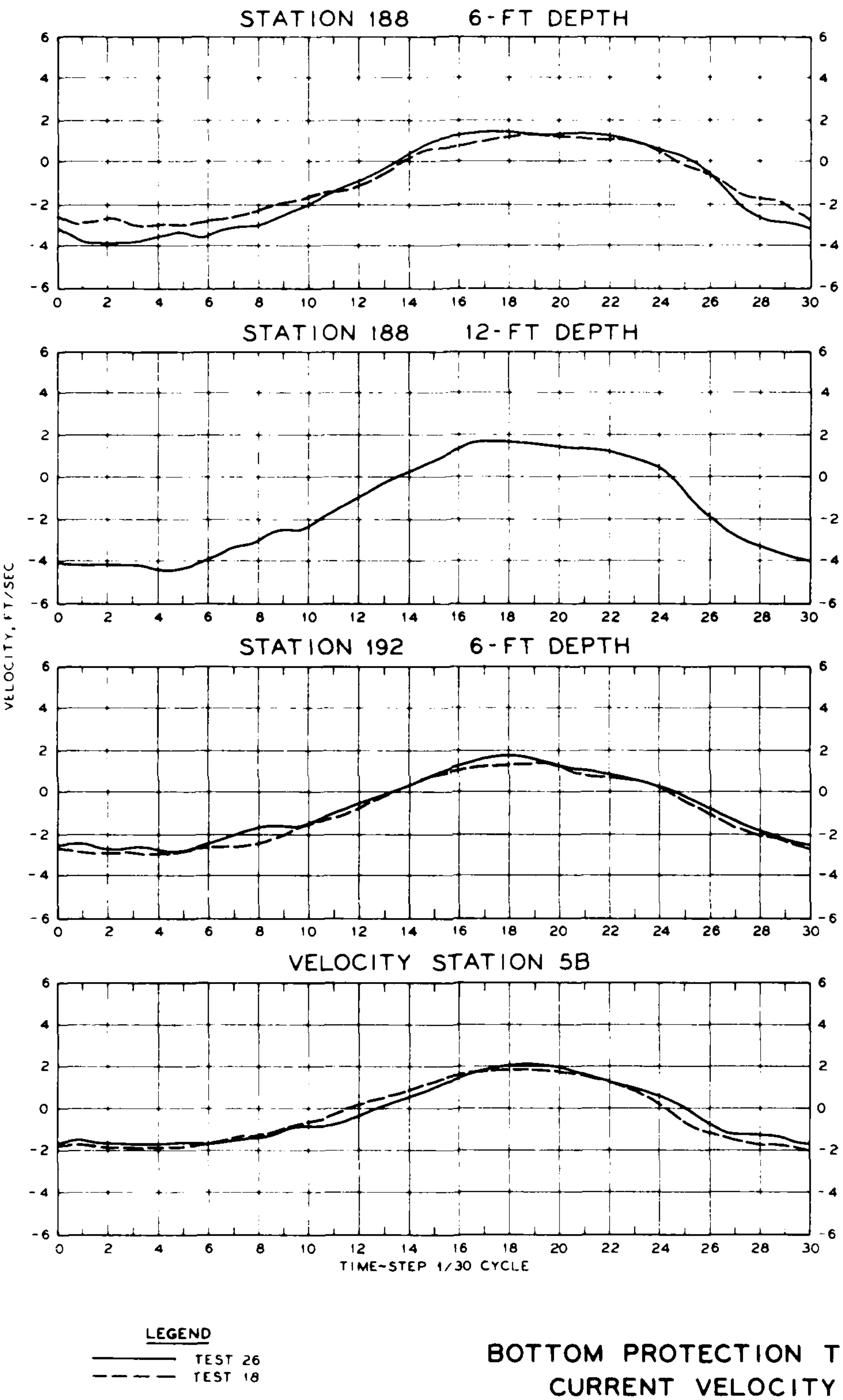
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 18 VS 26
STATIONS 145B AND 151



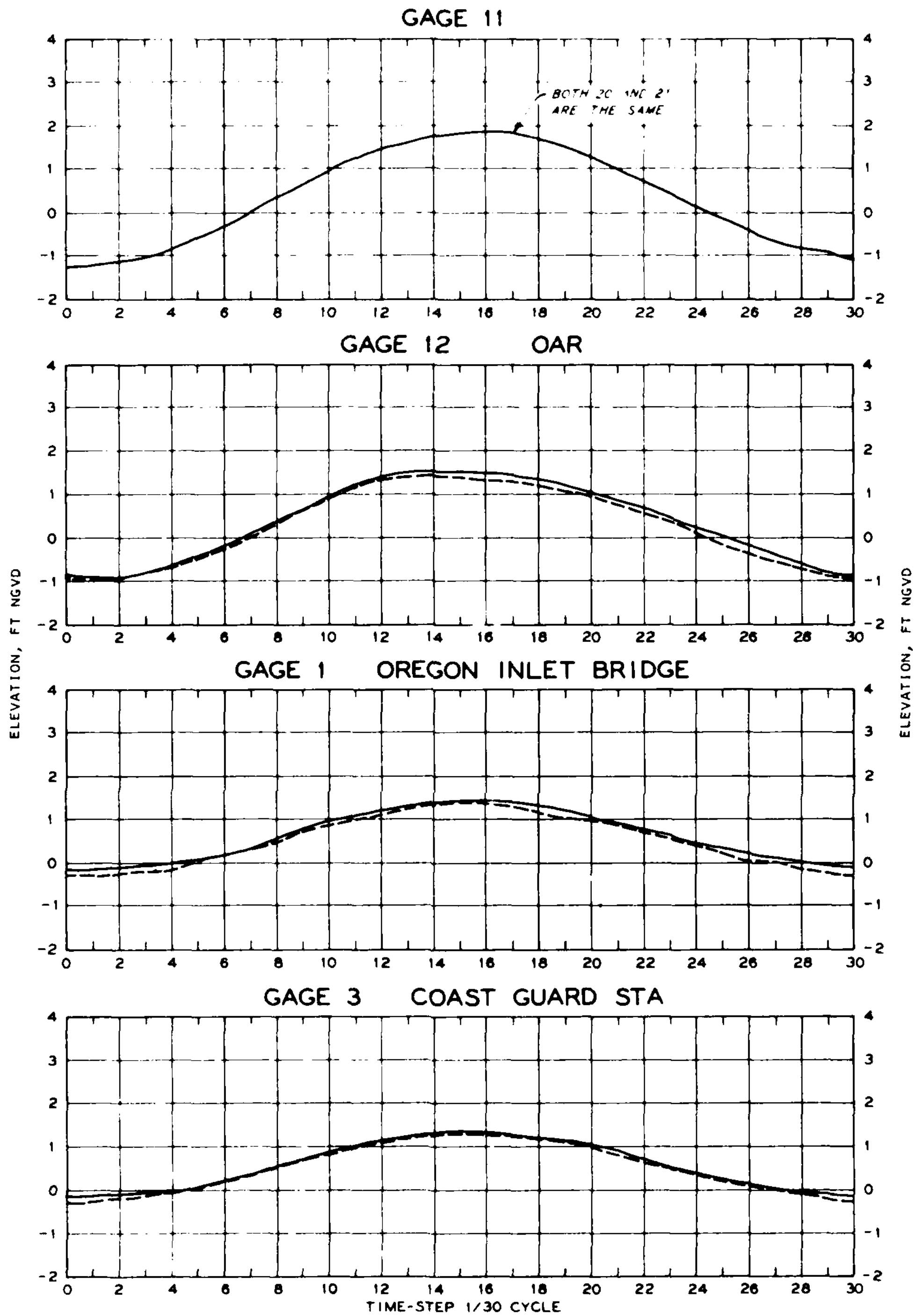
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 18 VS 26
STATIONS 155, 157, 162, AND 168



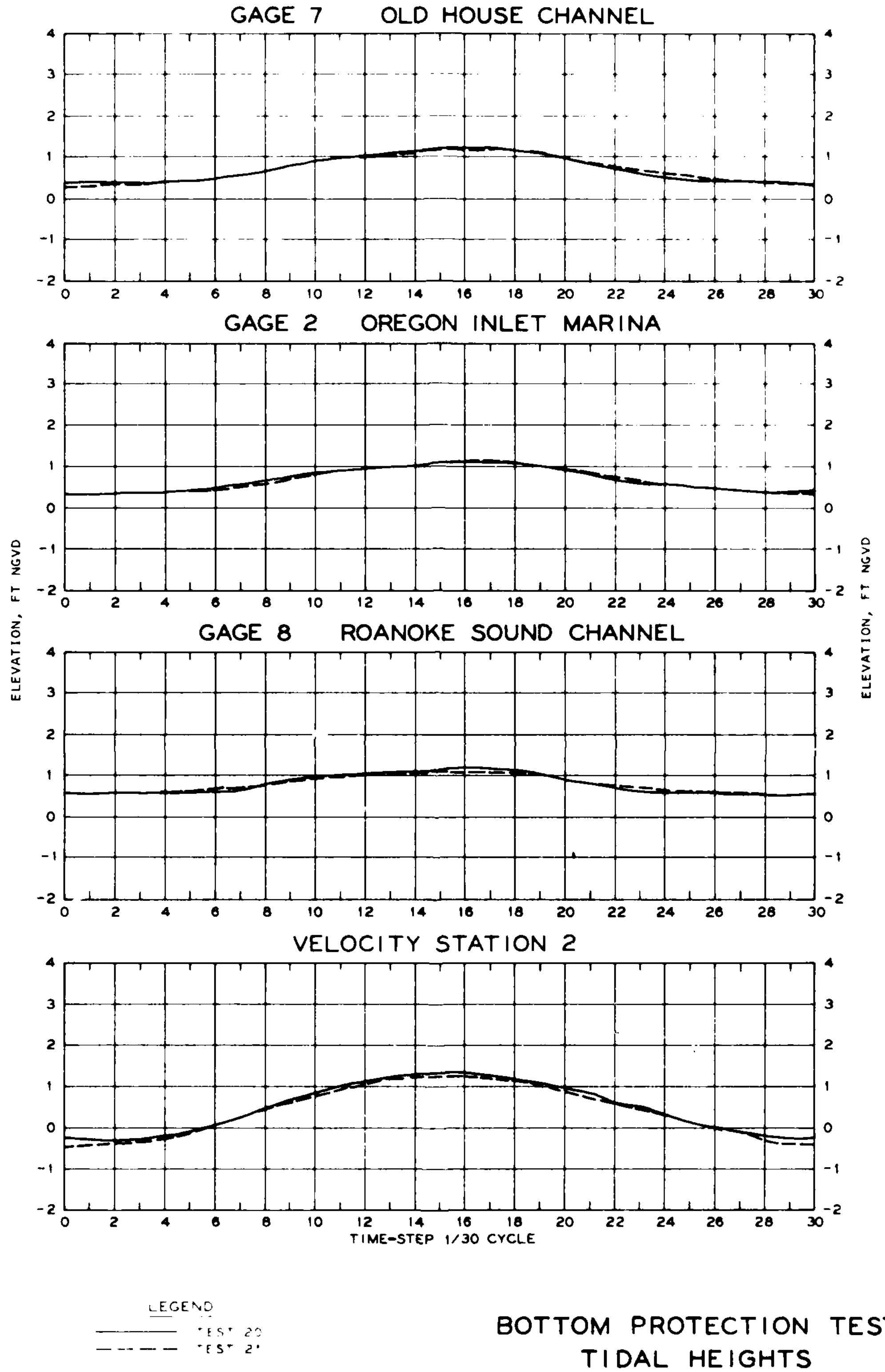
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 18 VS 26
STATIONS 175, 181, AND 141



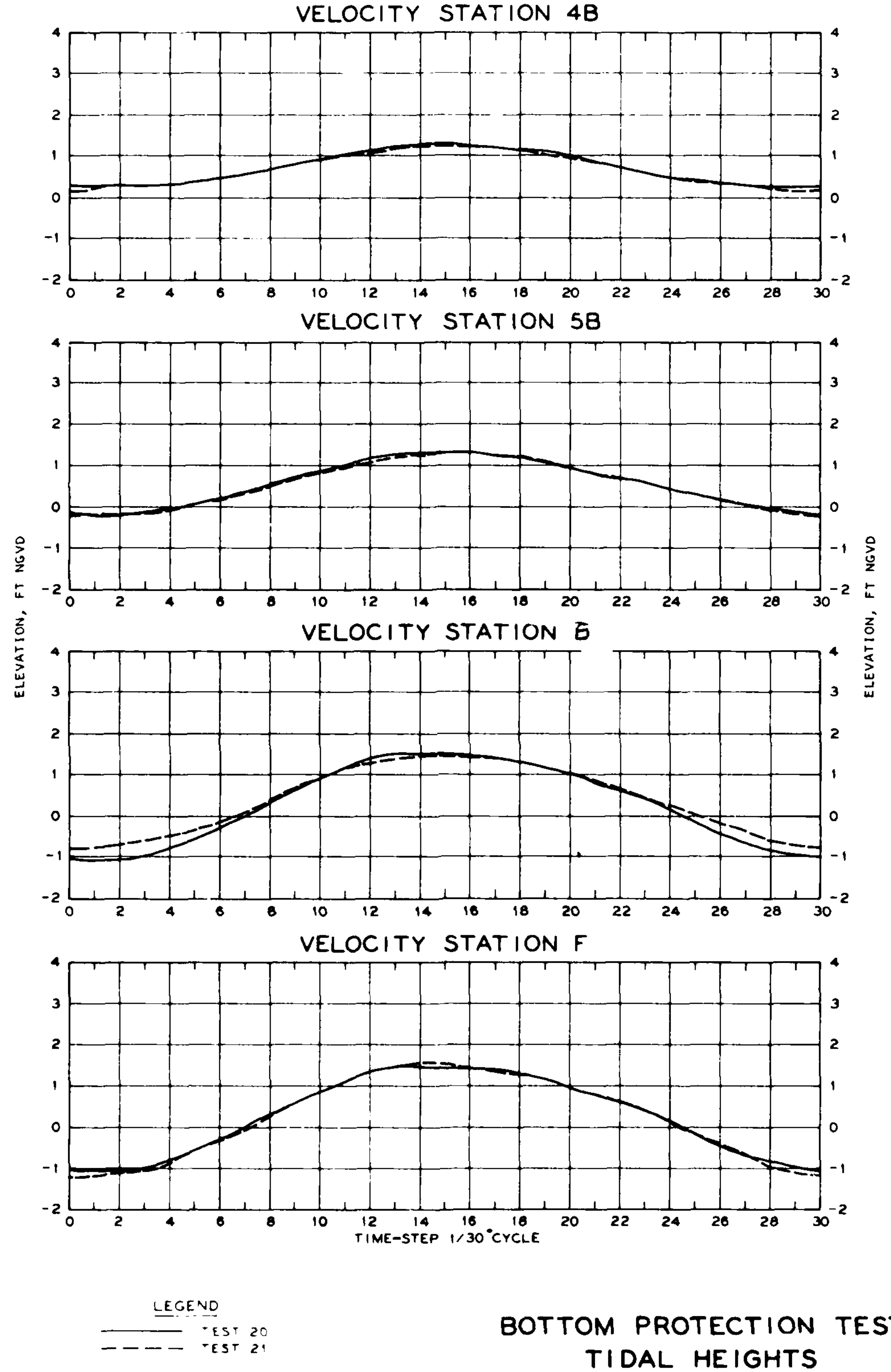
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 18 VS 26
STATIONS 188, 192, AND 5B



BOTTOM PROTECTION TEST
TIDAL HEIGHTS
TEST 20 VS 21
GAGES 11, 12, 1, AND 3

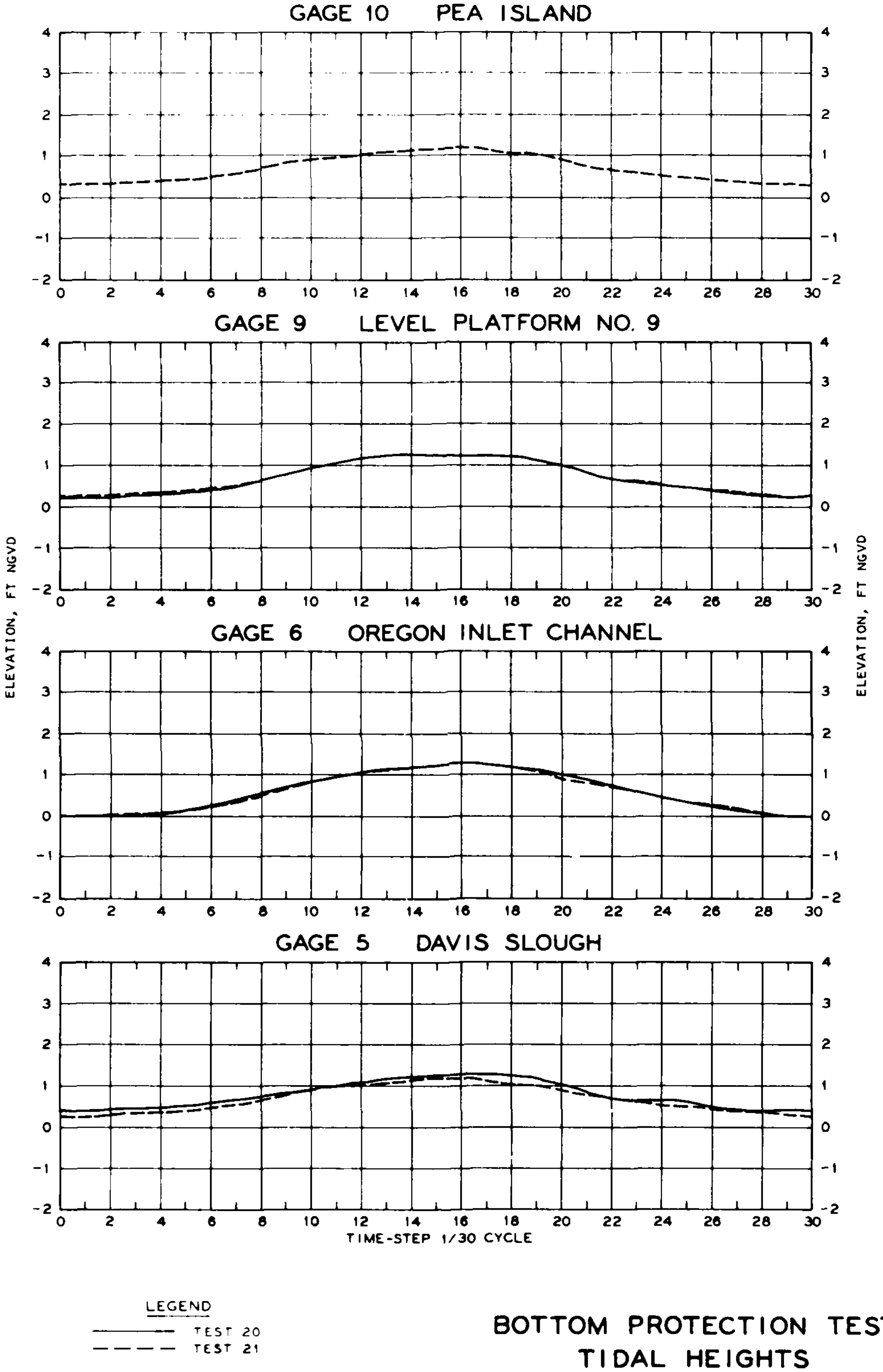


BOTTOM PROTECTION TEST
TIDAL HEIGHTS
TEST 20 VS 21
GAGES 7, 2, 8, AND VEL STA 2

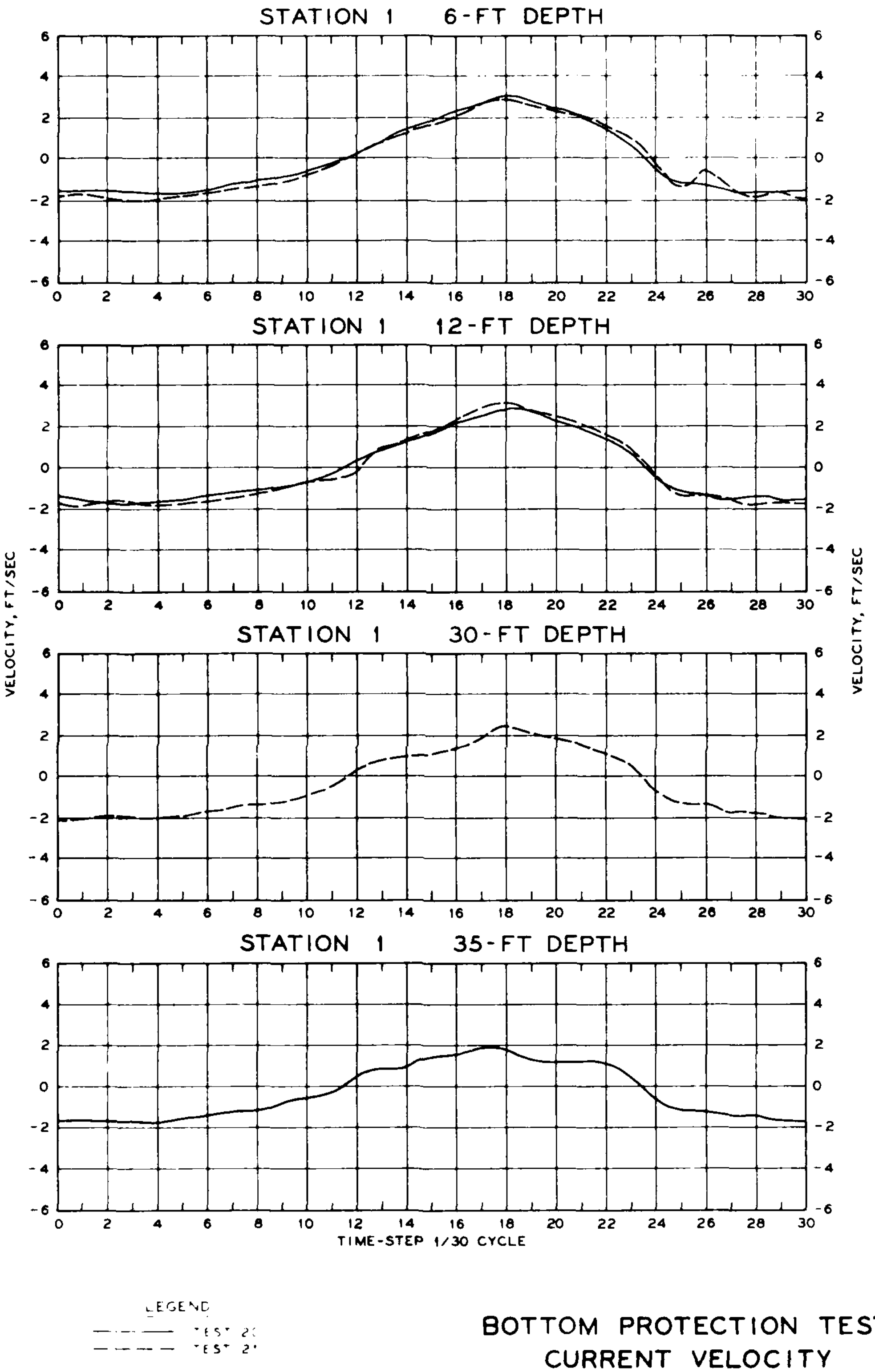


BOTTOM PROTECTION TEST
TIDAL HEIGHTS
TEST 20 VS 21
VELOCITY STATIONS 4B, 5B, B, AND F

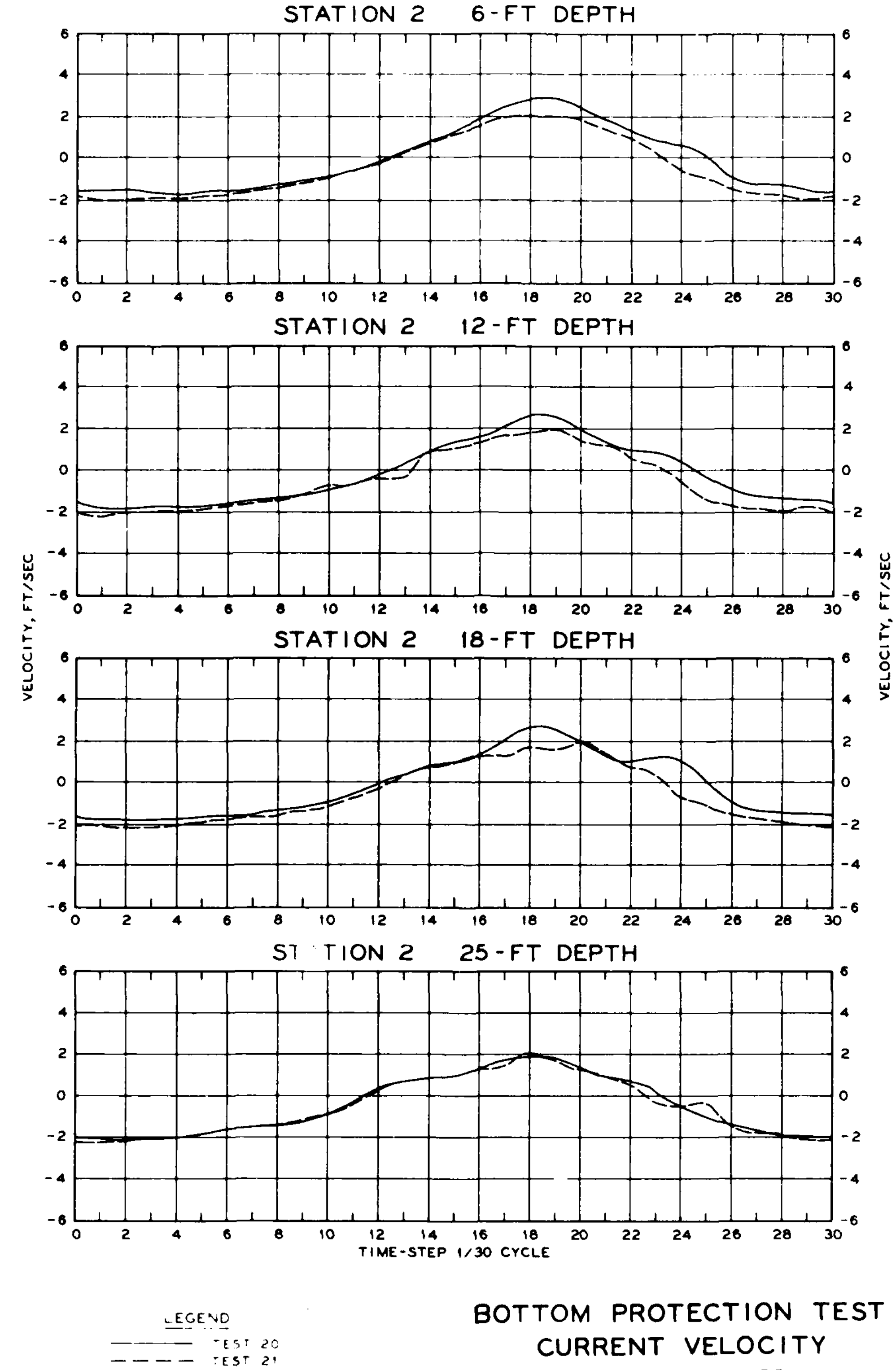
PLATE 226



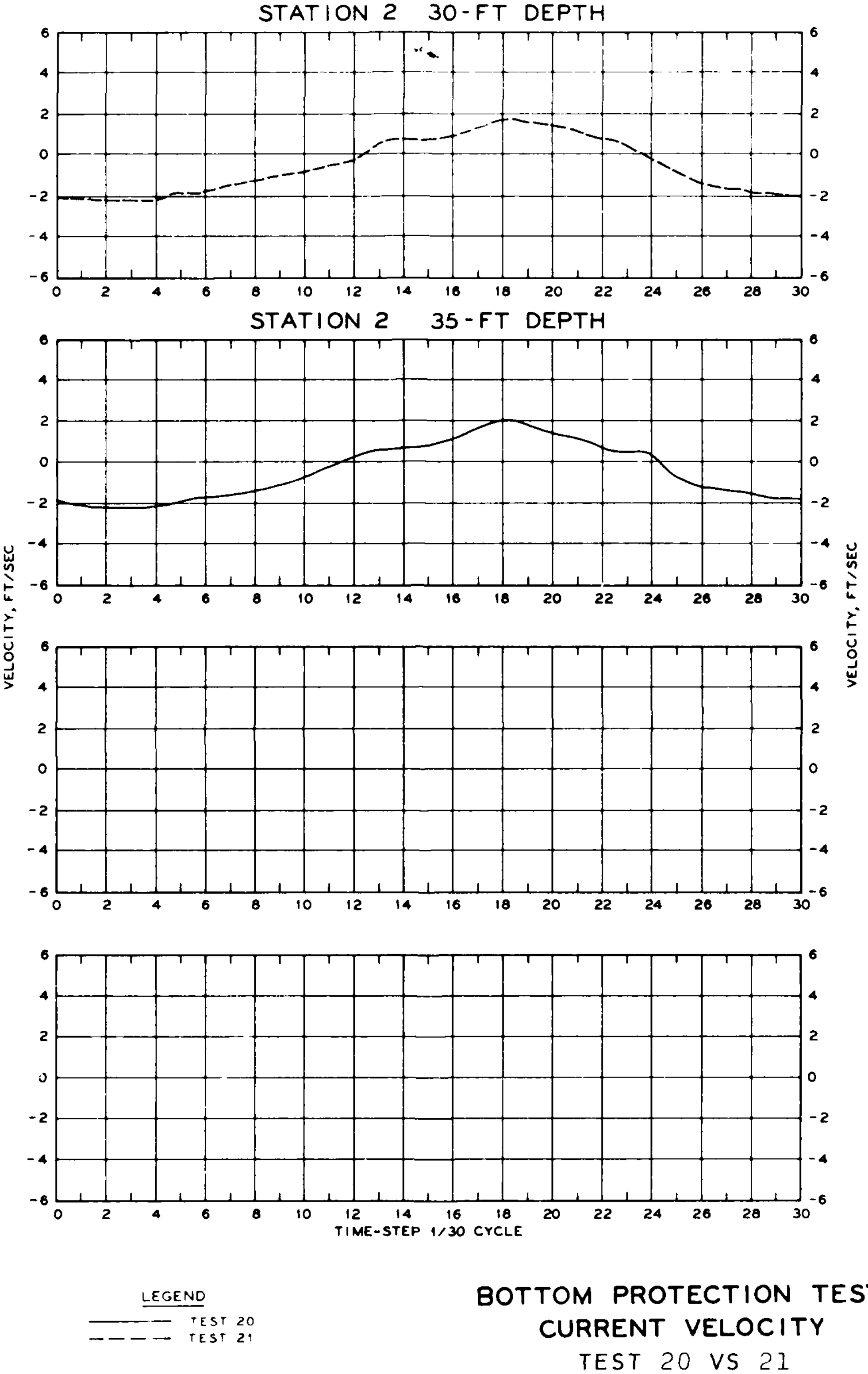
BOTTOM PROTECTION TEST
TIDAL HEIGHTS
TEST 20 VS 21
GAGES 10, 9, 6, AND 5



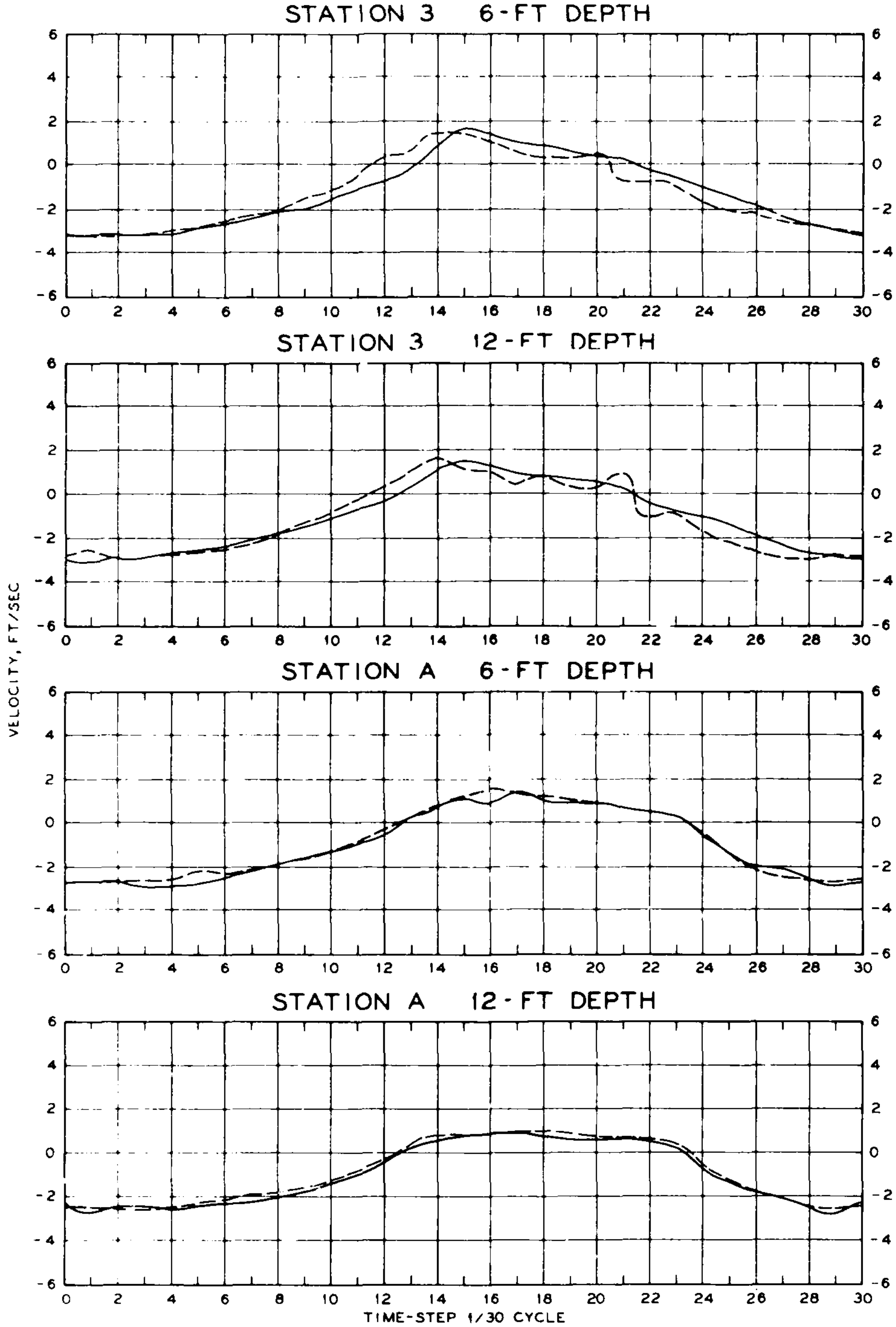
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 20 VS 21
STATIONS 1



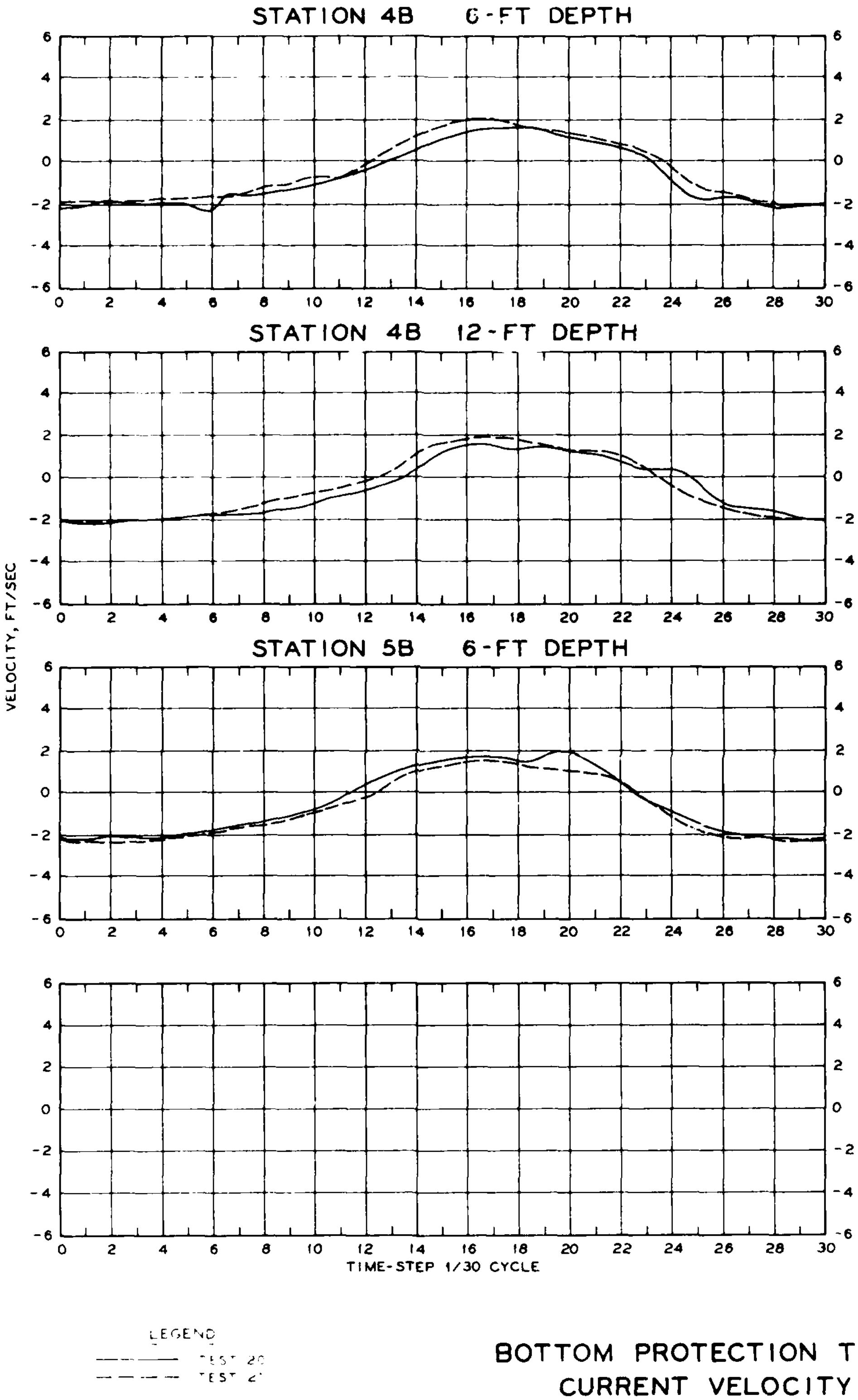
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 20 VS 21
STATION 2
6-, 12-, 18-, AND 25-FT DEPTHS



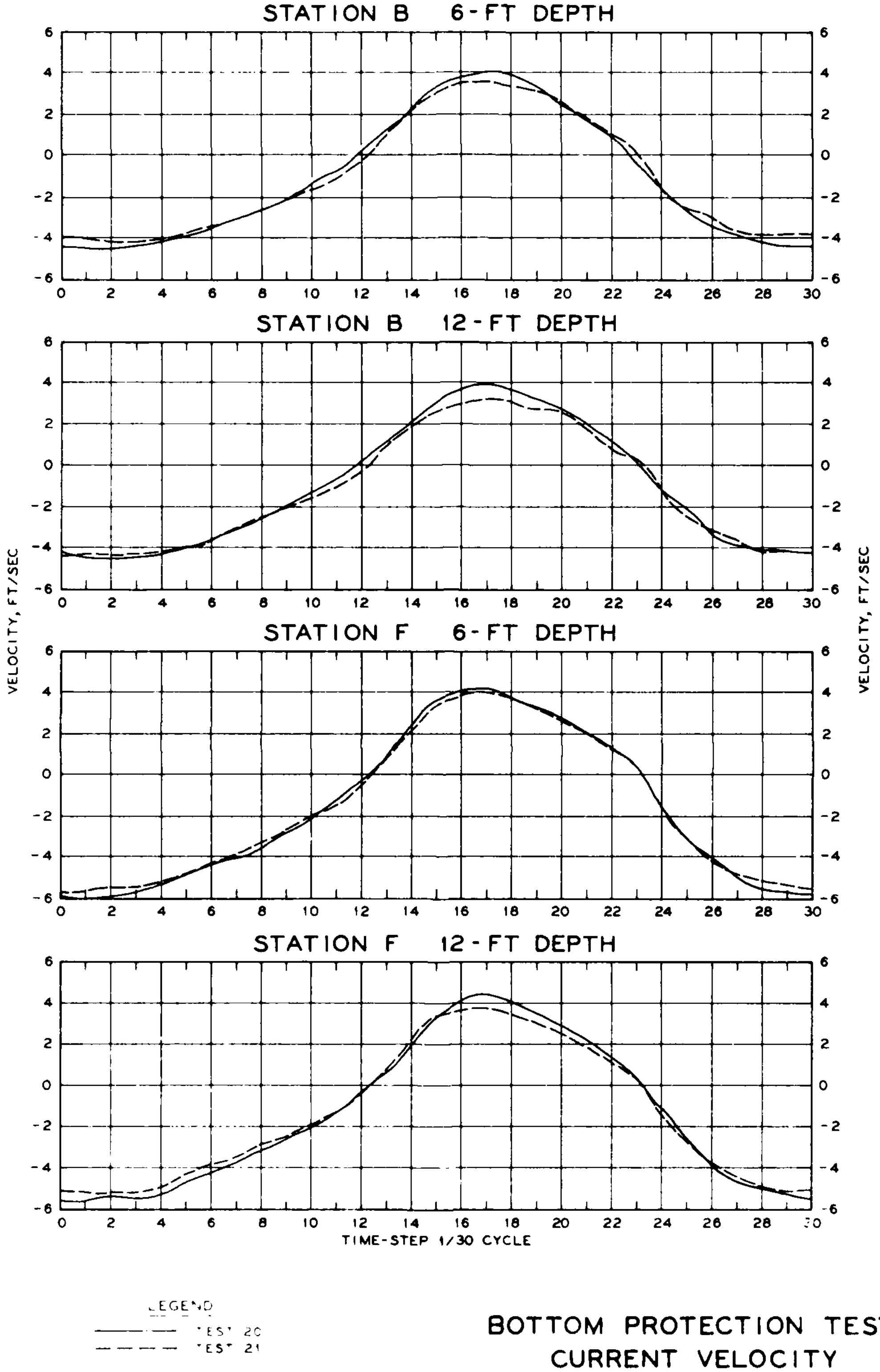
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 20 VS 21
STATION 2
30- AND 35-FT DEPTHS



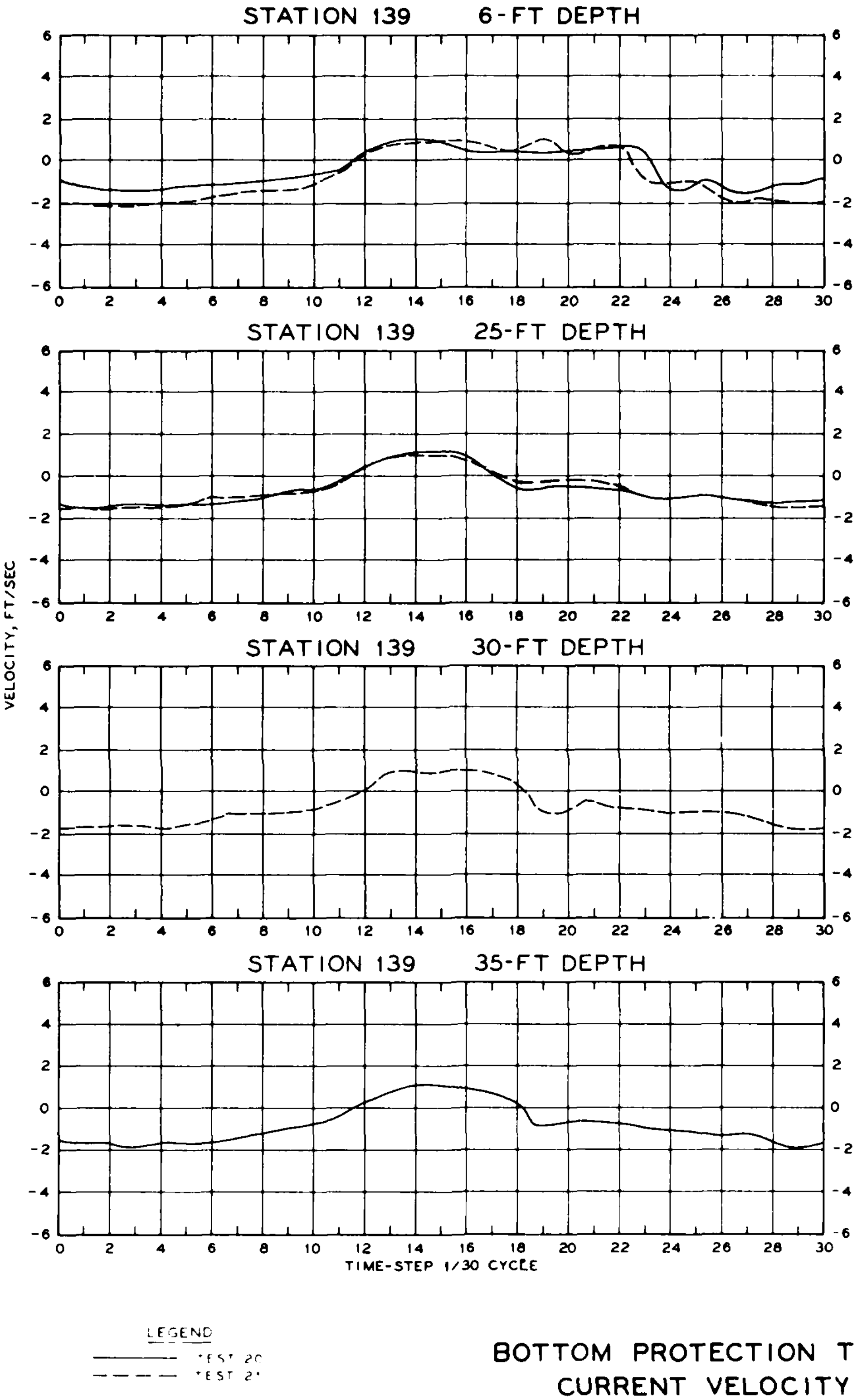
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 20 VS 21
STATIONS 3 AND A



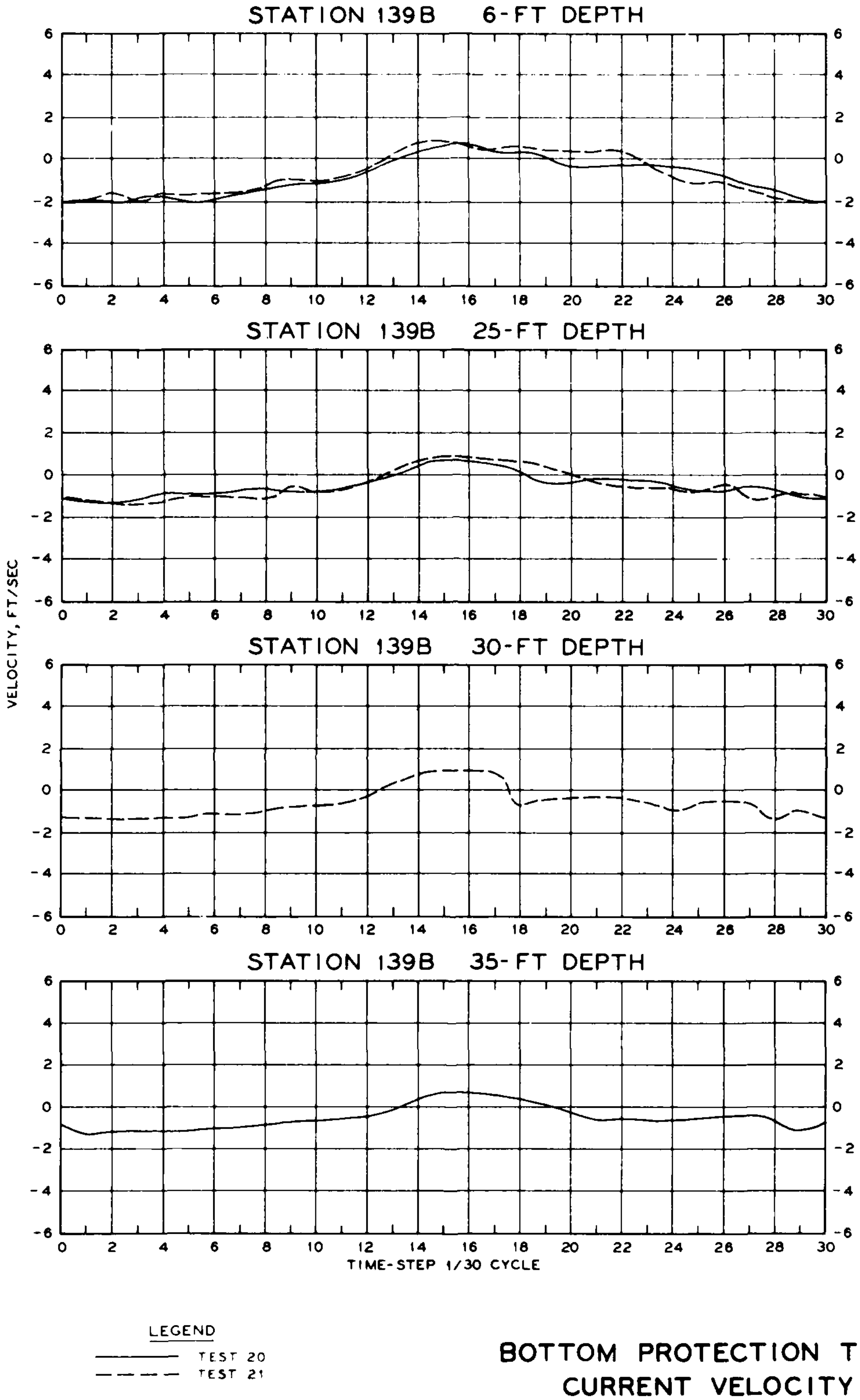
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 20 VS 21
STATIONS 4B AND 5B



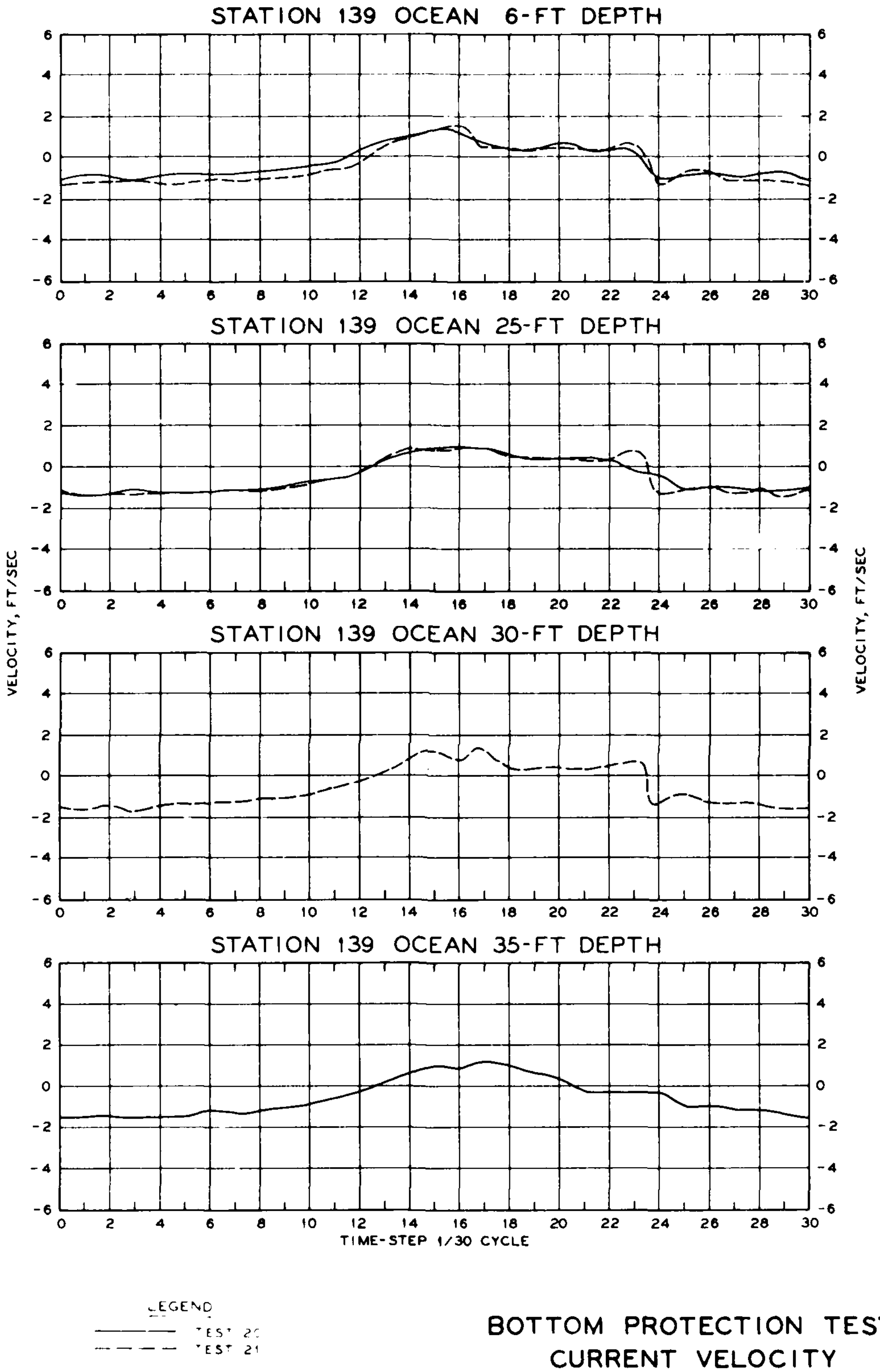
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 20 VS 21
STATIONS B AND F



BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 20 VS 21
STATION 139

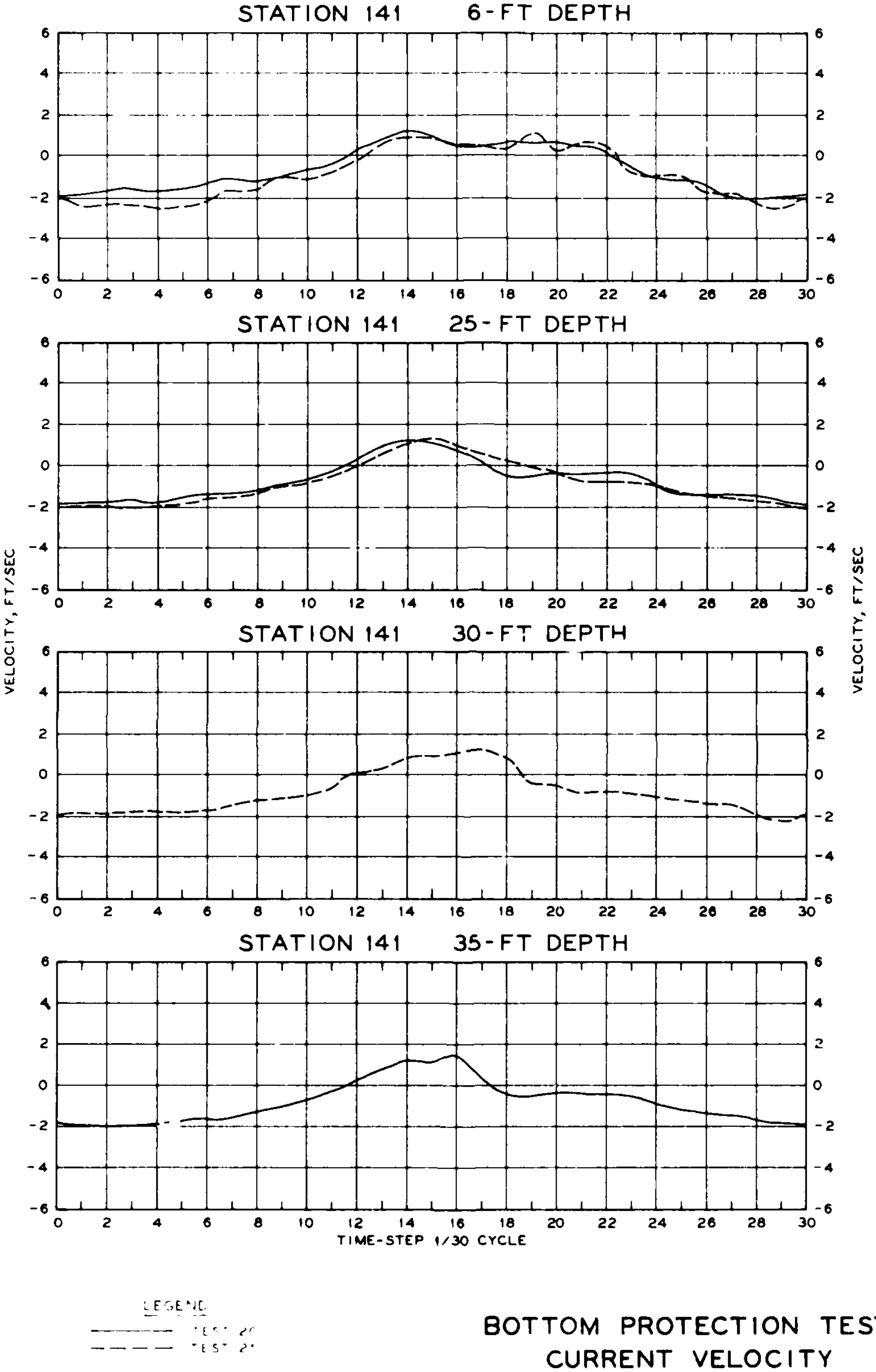


BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 20 VS 21
STATION 139B

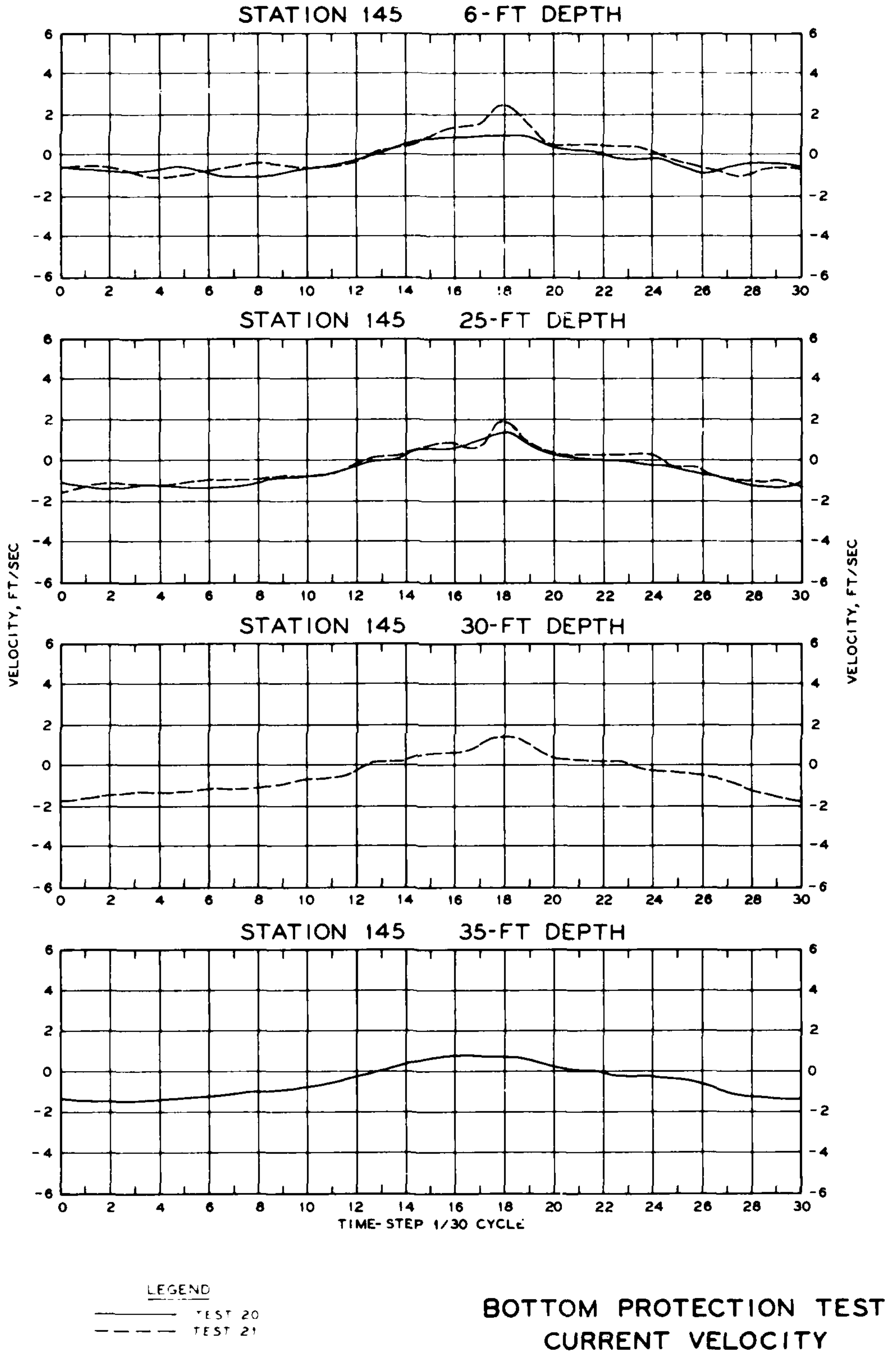


BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 20 VS 21
STATION 139 OCEAN

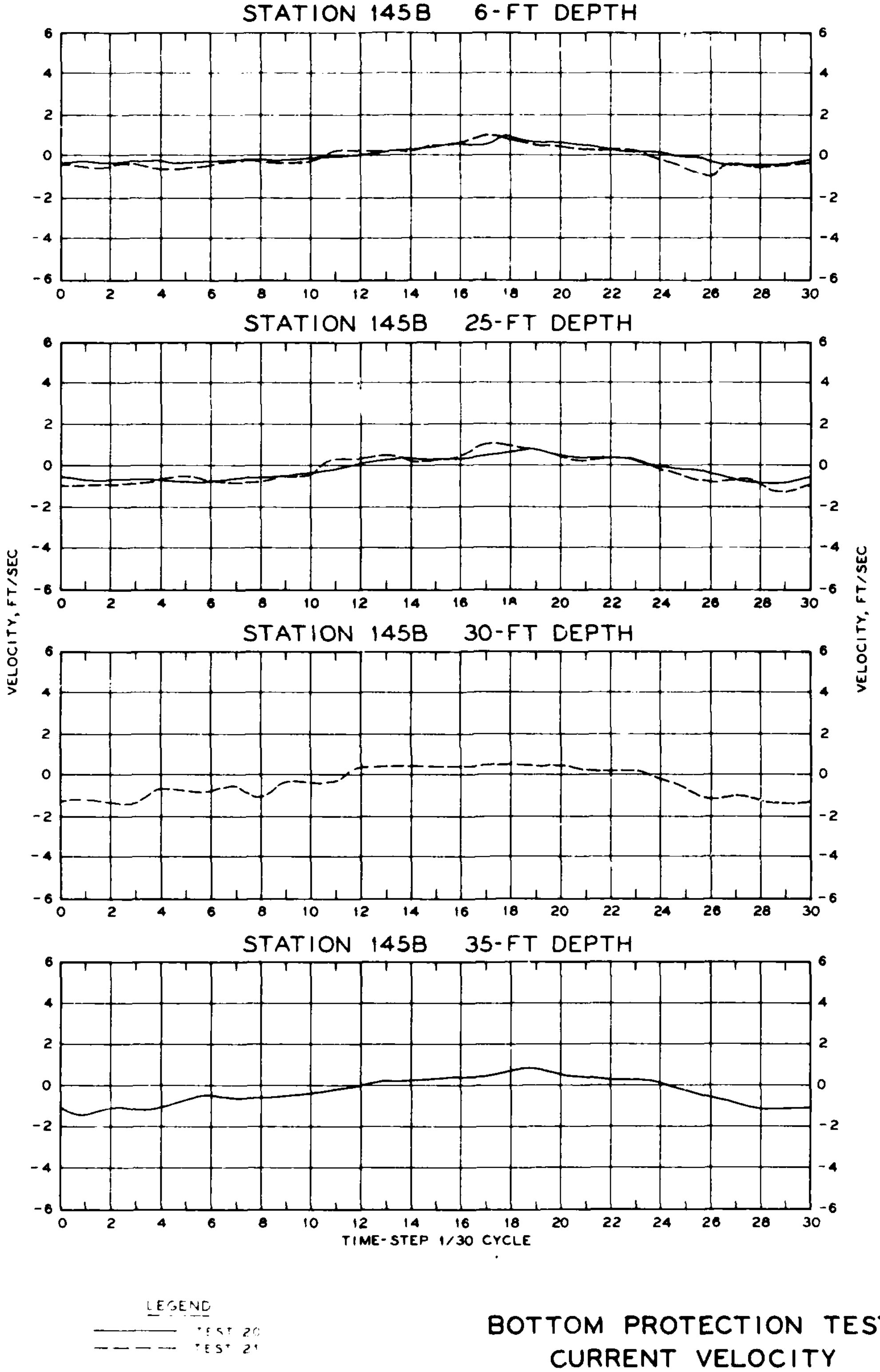
PLATE 236



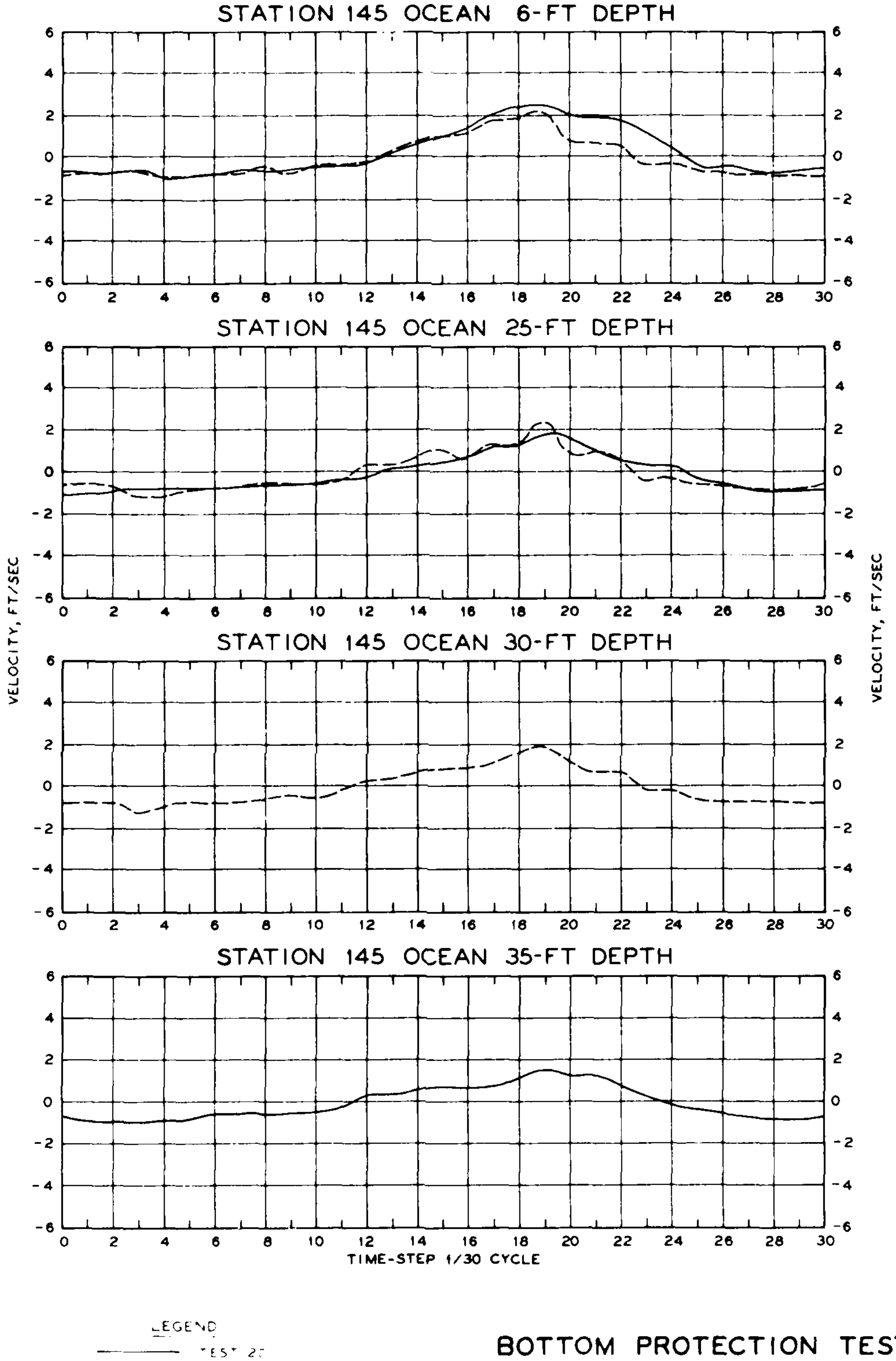
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 20 VS 21
STATION 141



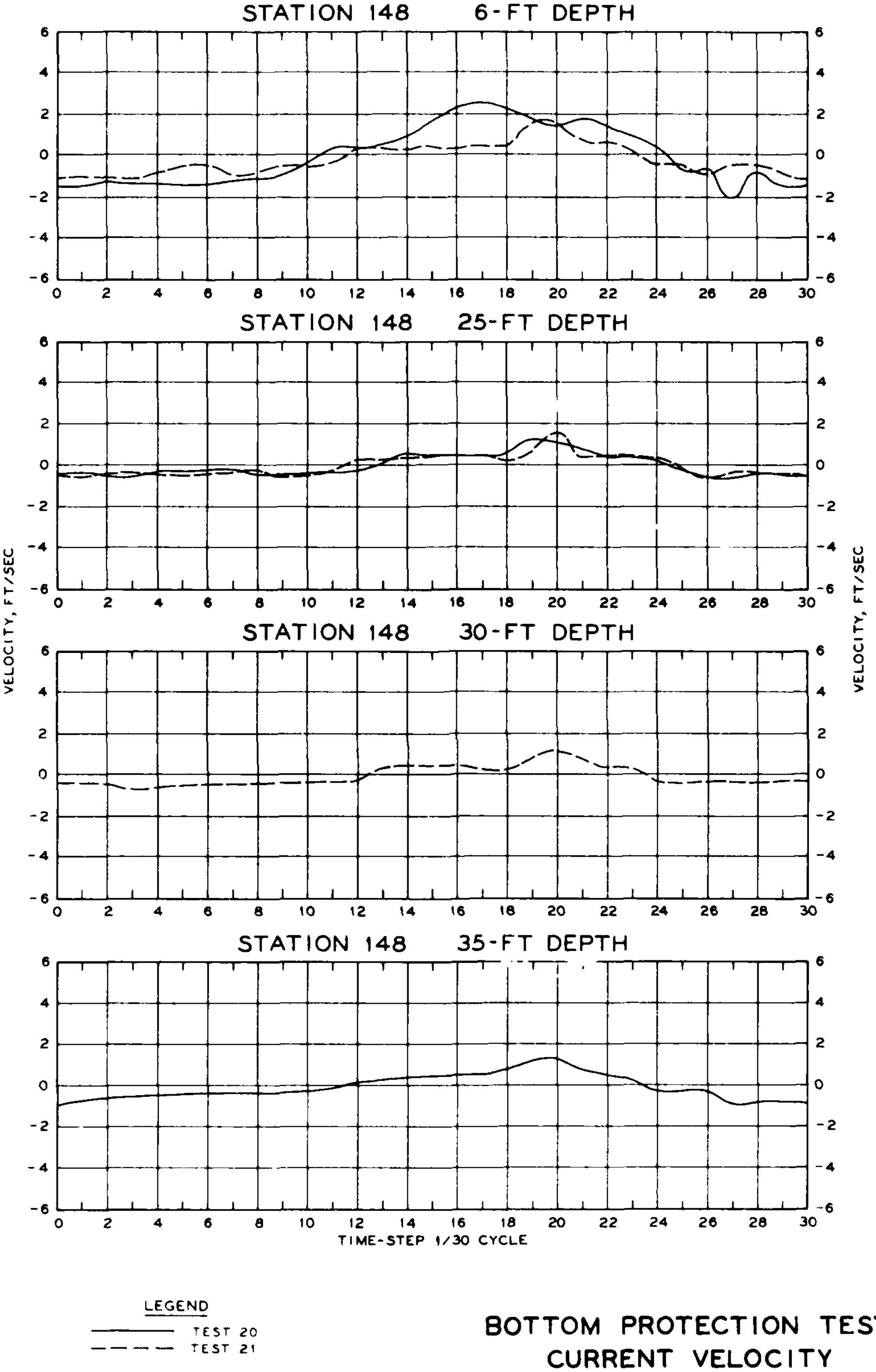
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 20 VS 21
STATION 145



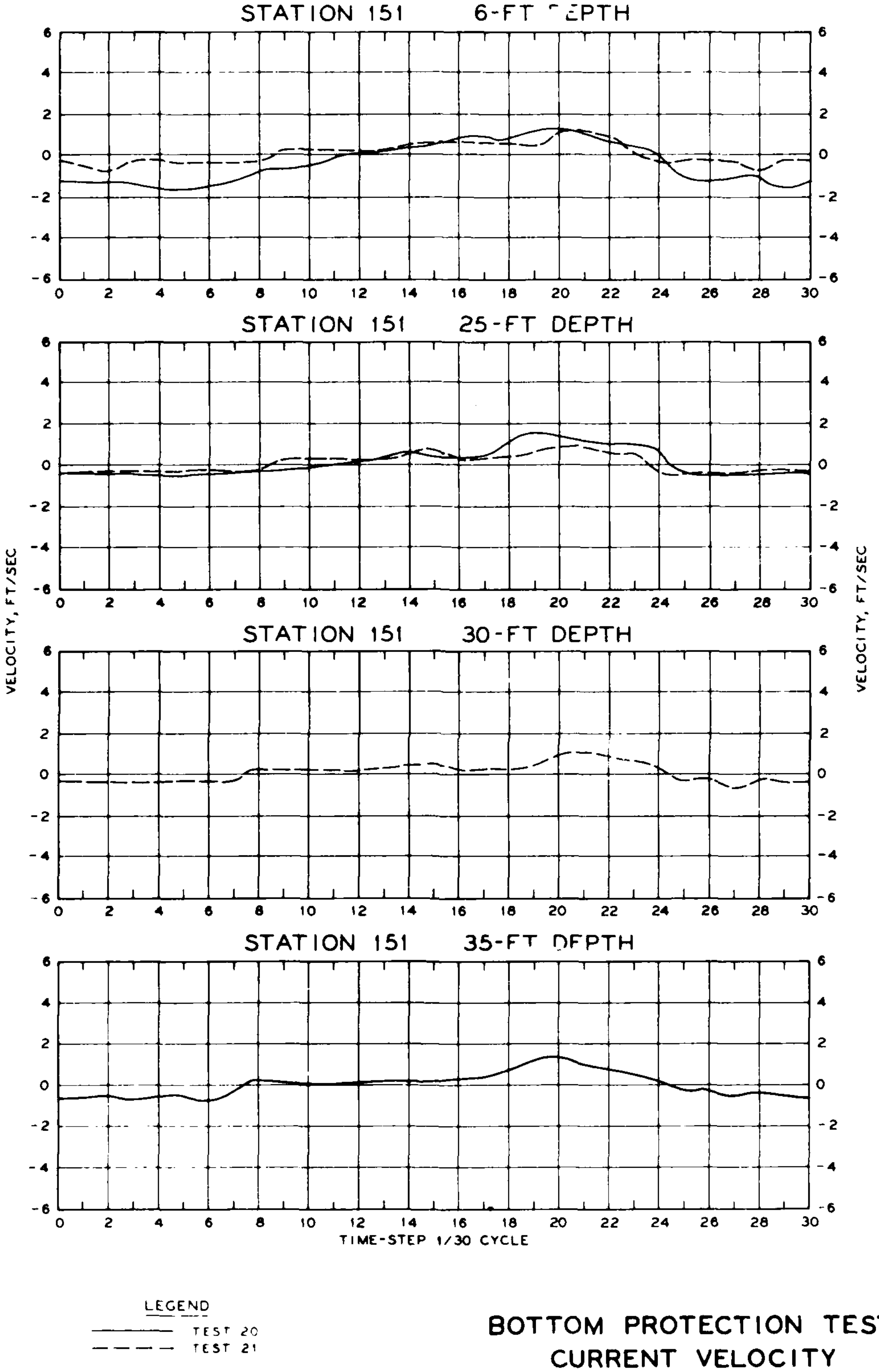
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 20 VS 21
STATION 145B



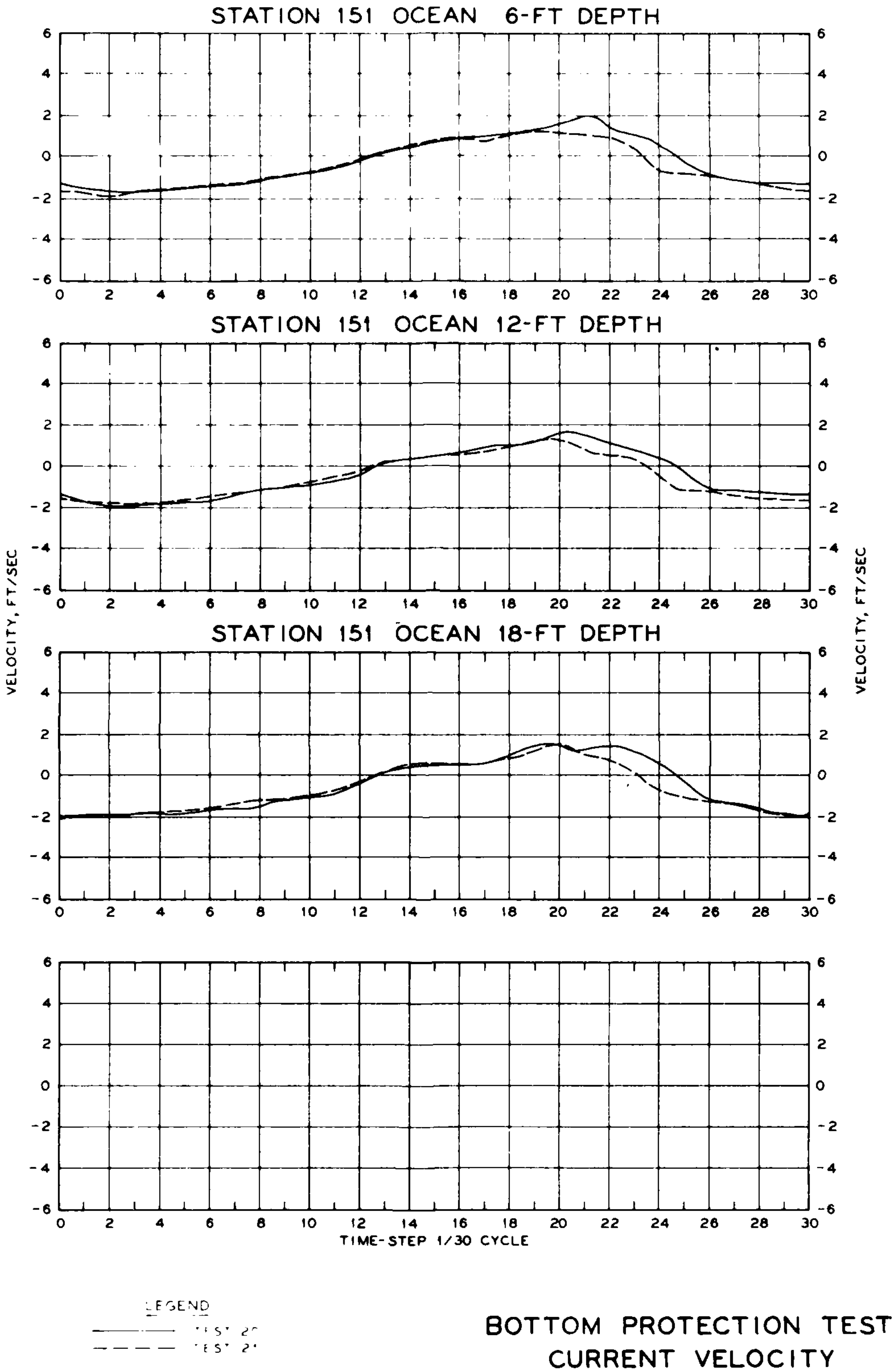
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 20 VS 21
STATION 145 OCEAN



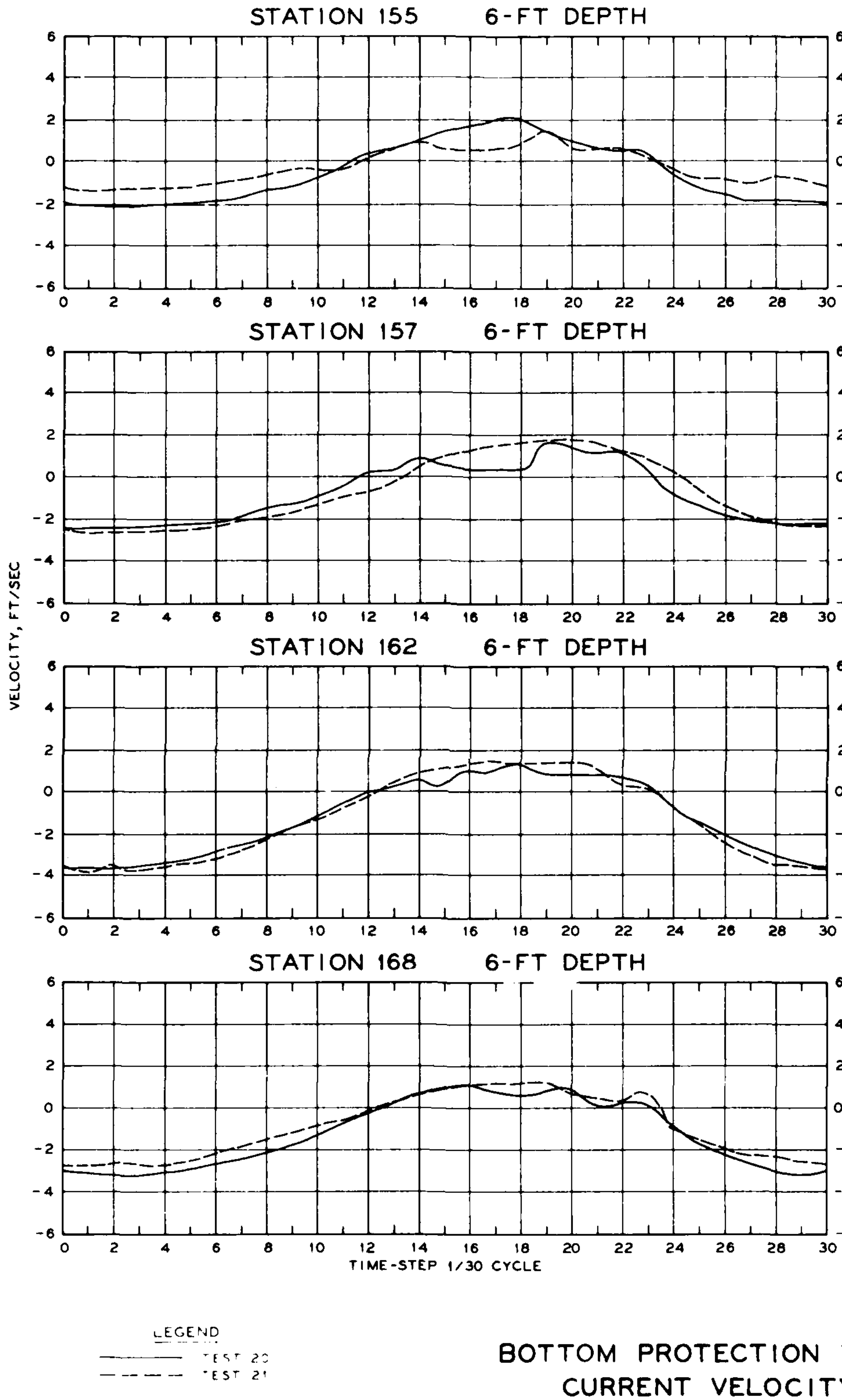
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 20 VS 21
STATION 148



BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 20 VS 21
STATION 151

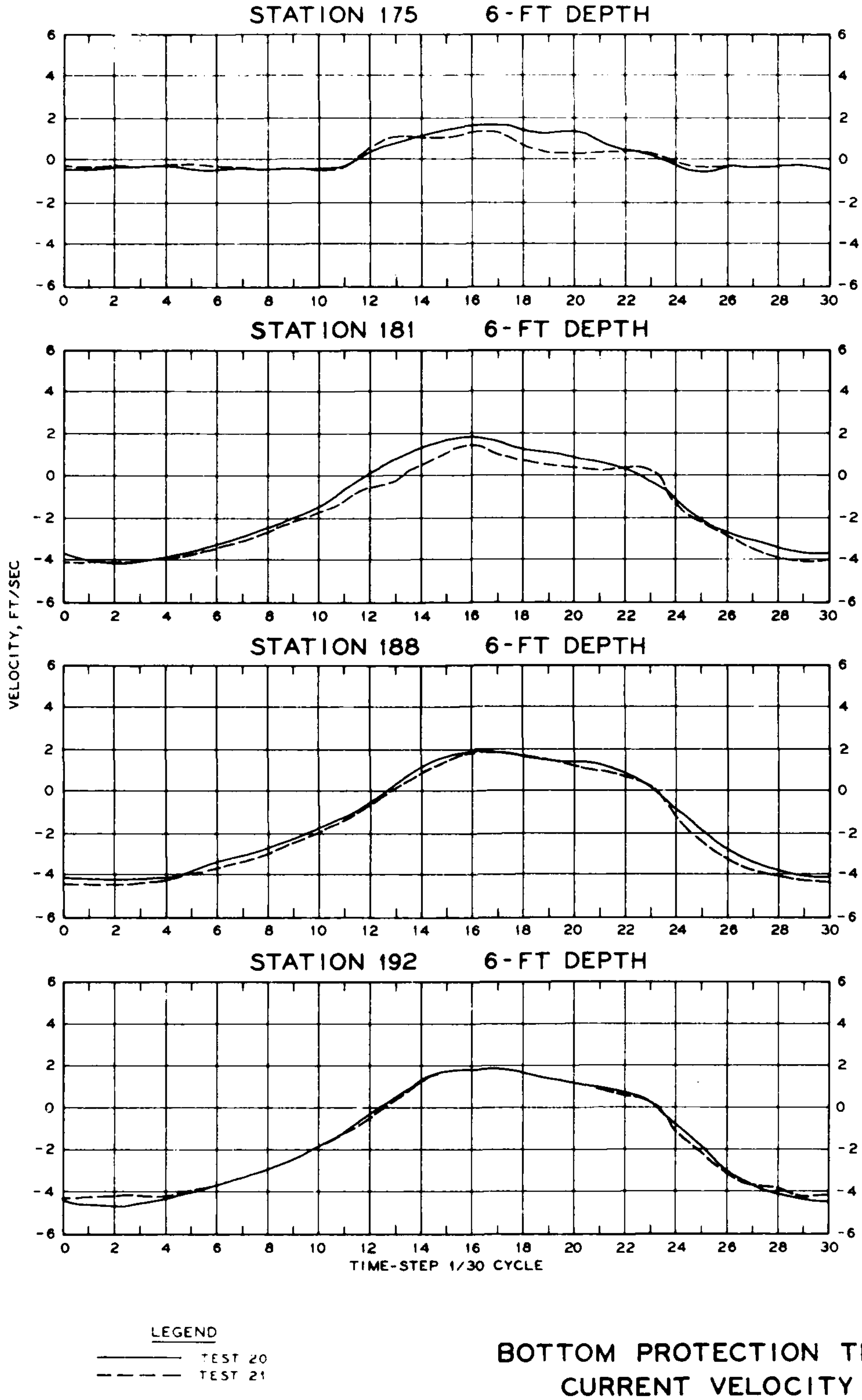


BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 20 VS 21
STATION 151 OCEAN

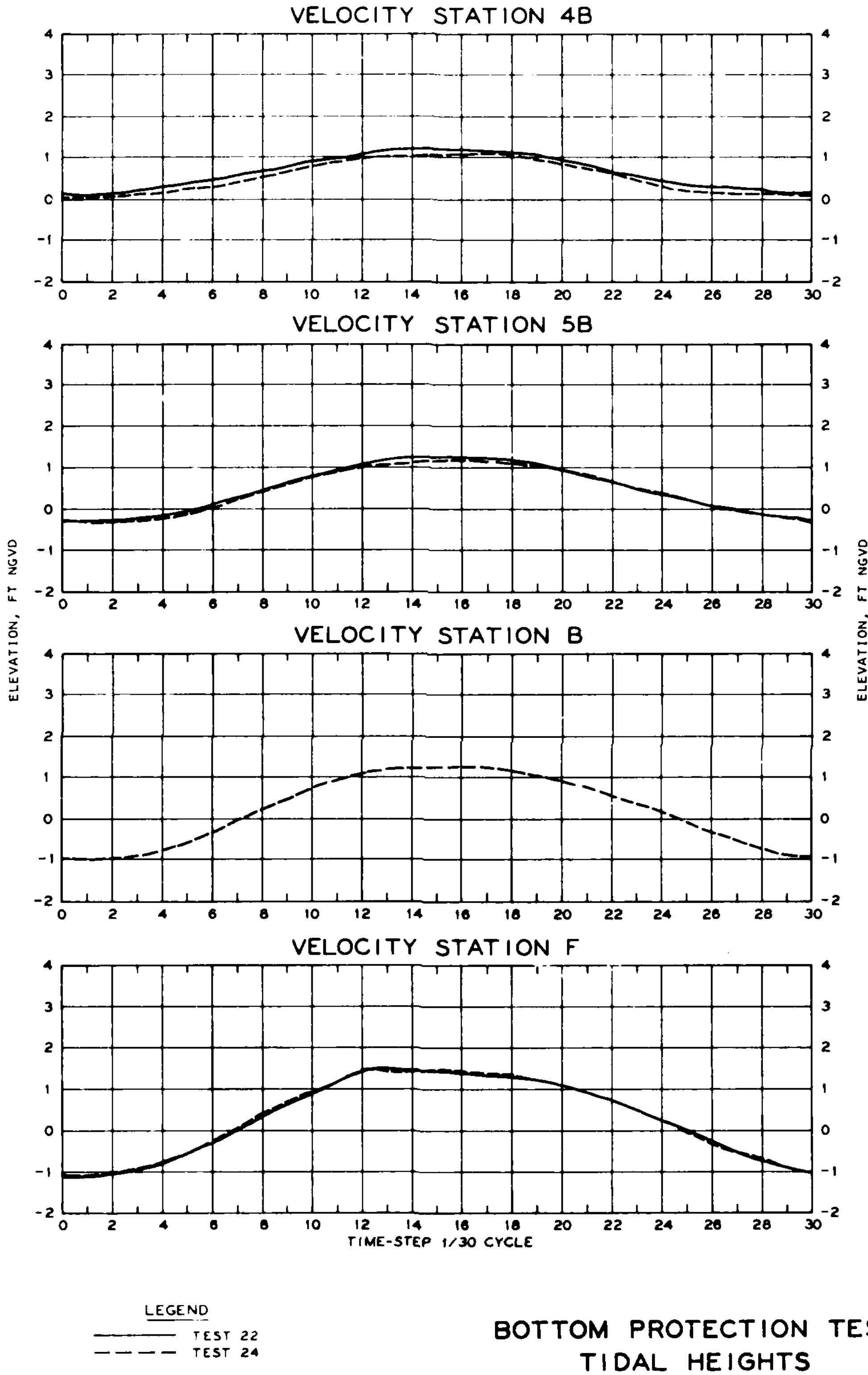


BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 20 VS 21
STATIONS 155, 157, 162, AND 168

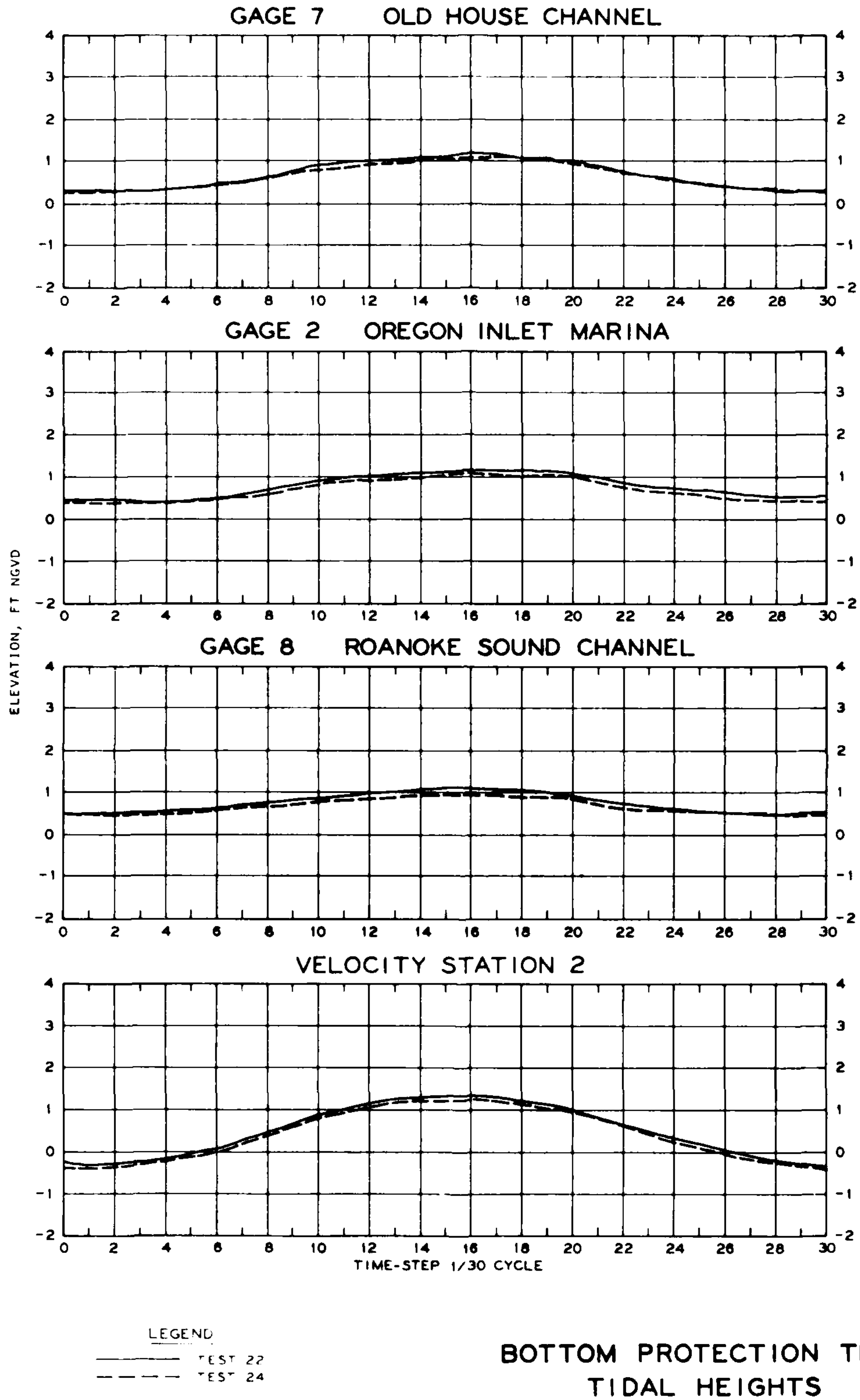
PLATE 244



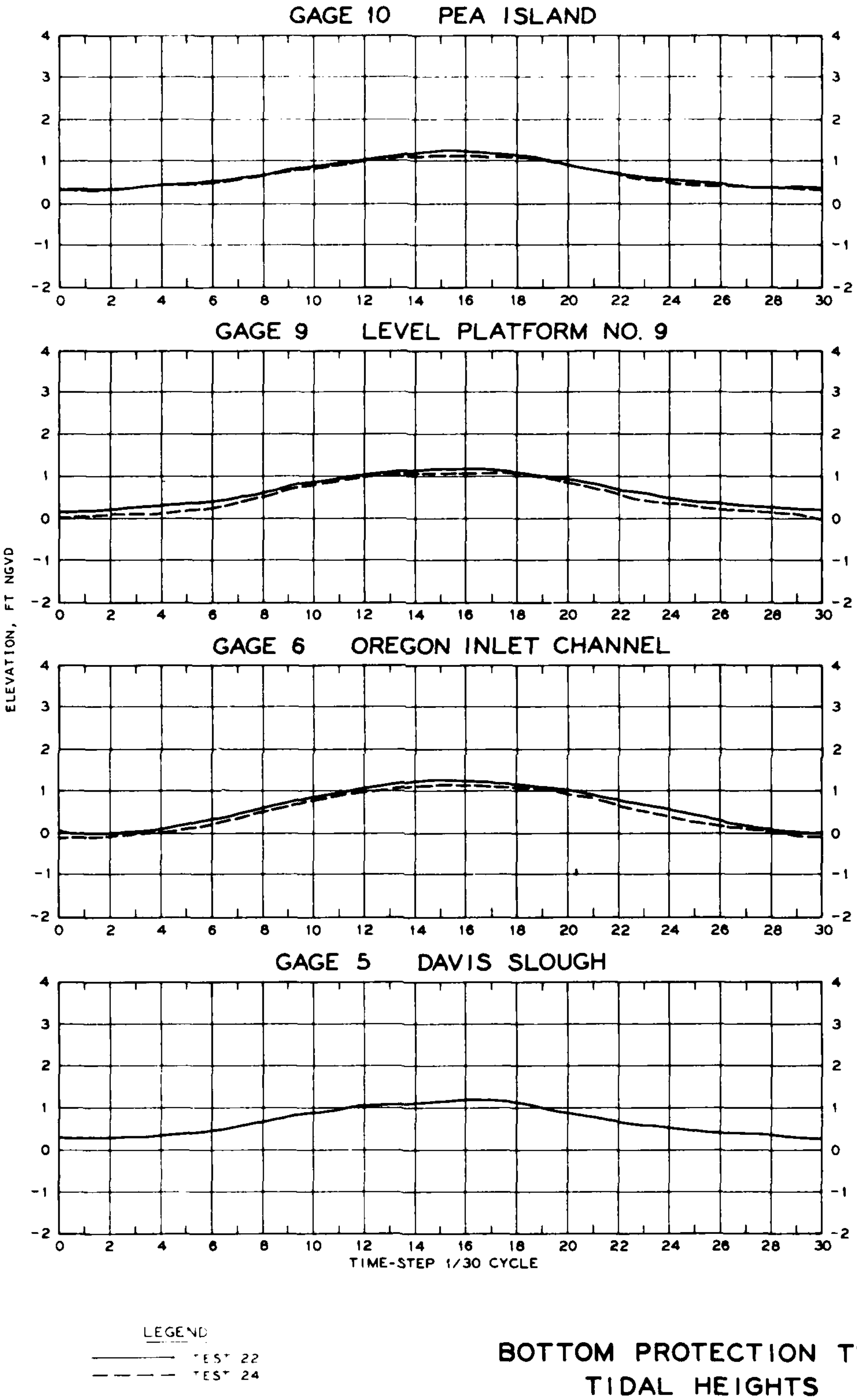
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 20 VS 21
STATIONS 175, 181, 188, AND 192



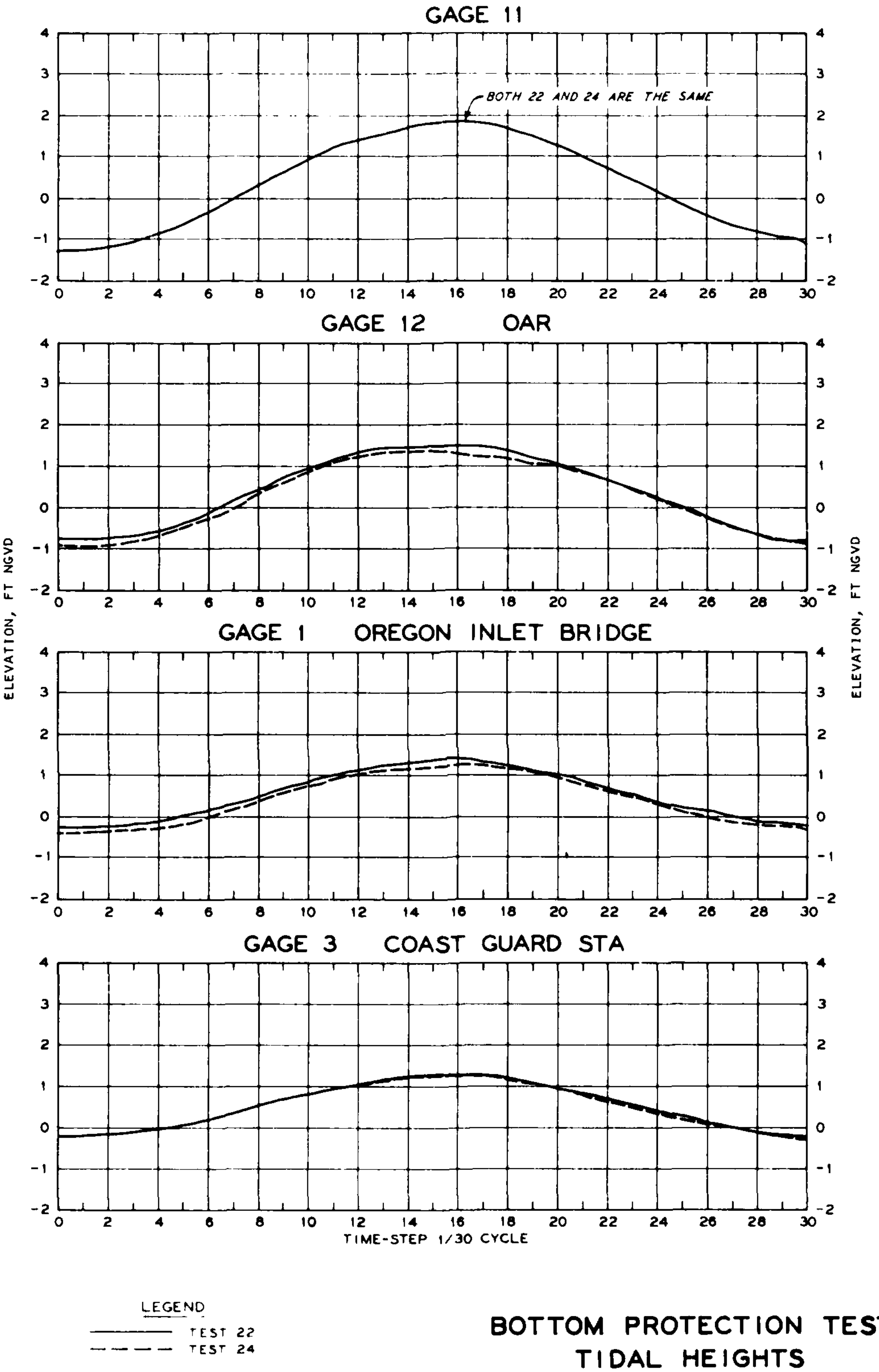
BOTTOM PROTECTION TEST
TIDAL HEIGHTS
TEST 22 VS 24
VELOCITY STATIONS 4B, 5B, B, AND F



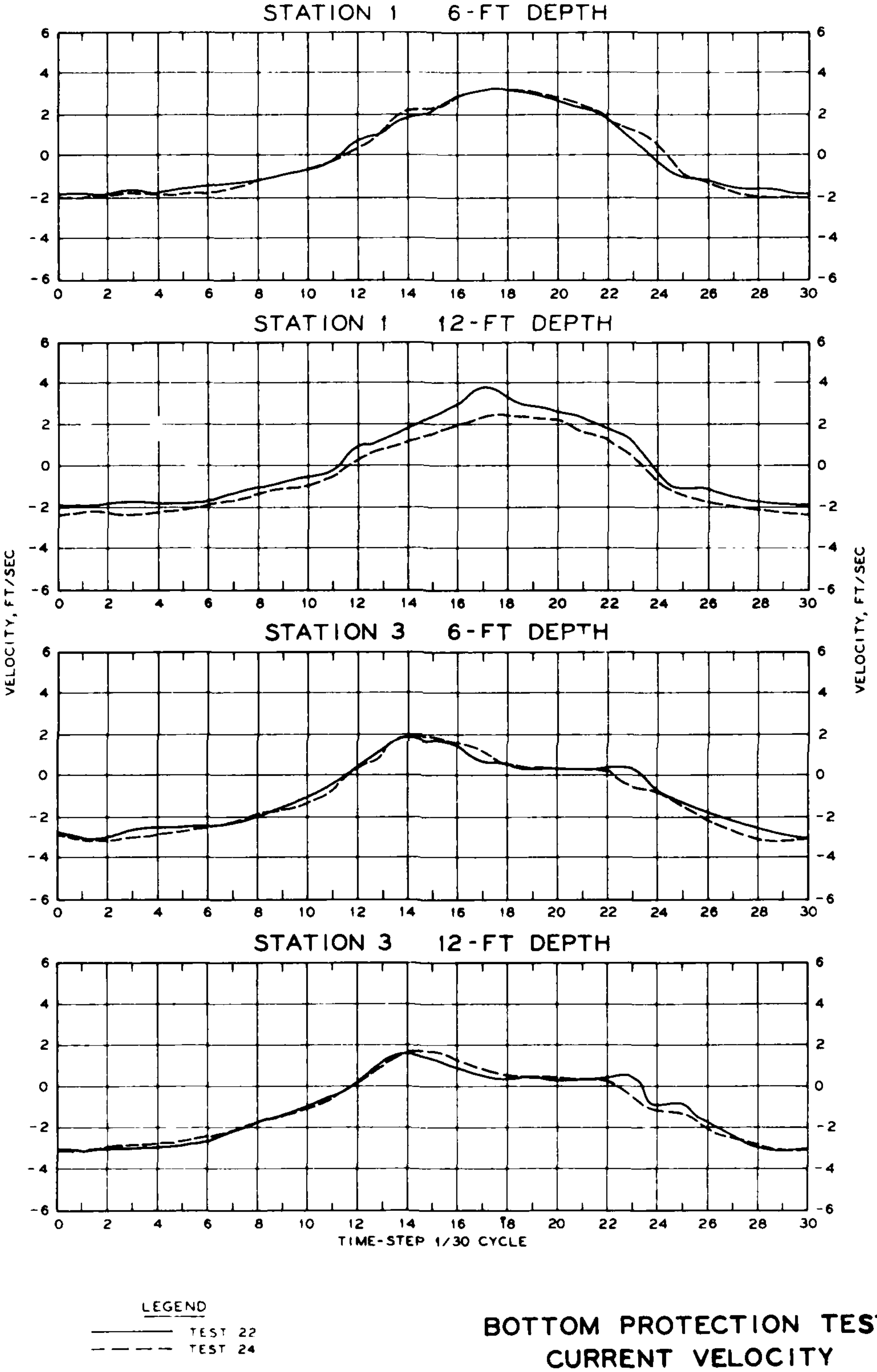
BOTTOM PROTECTION TEST
TIDAL HEIGHTS
TEST 22 VS 24
GAGES 7, 2, AND 8



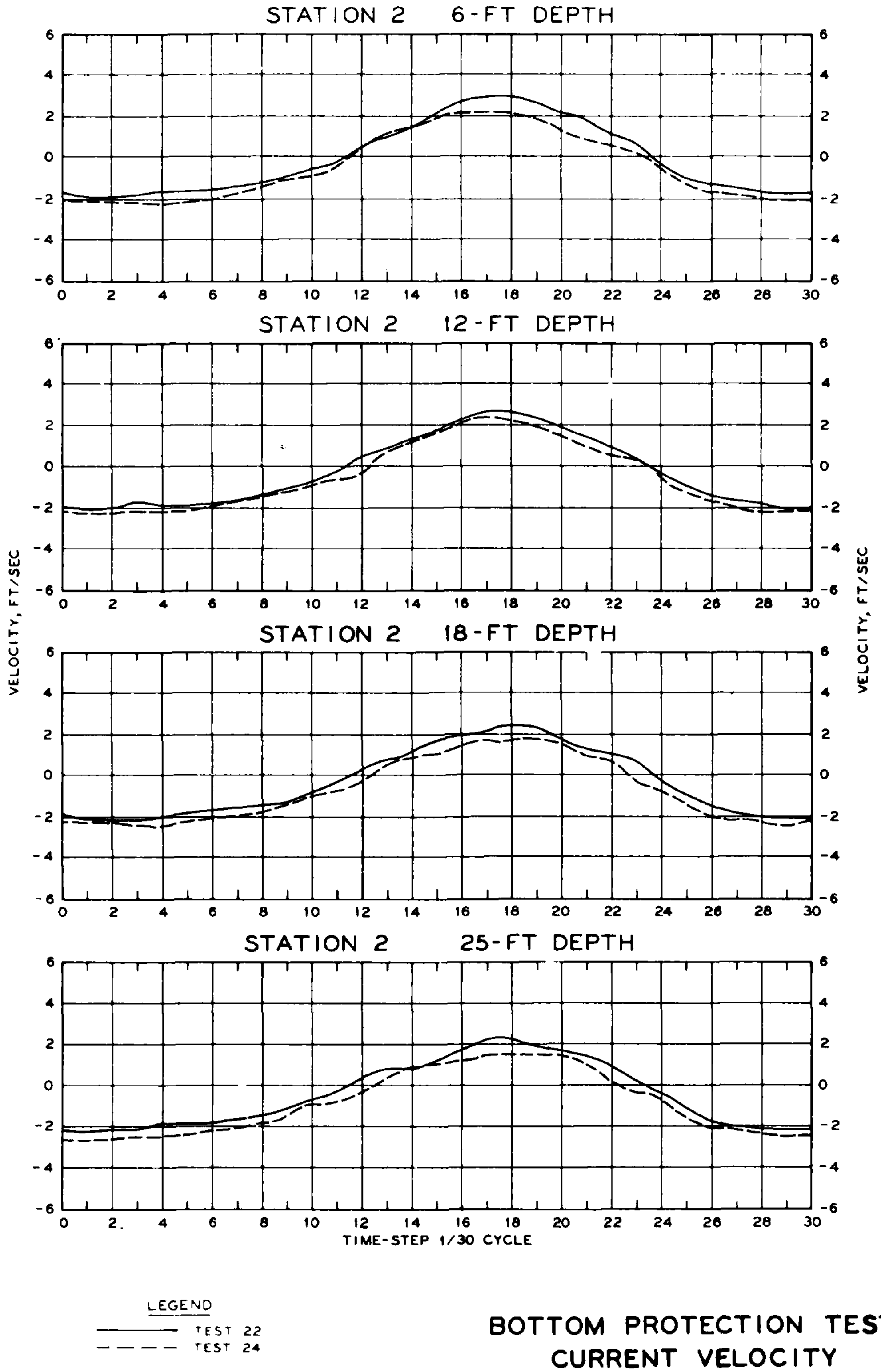
BOTTOM PROTECTION TEST
TIDAL HEIGHTS
TEST 22 VS 24
GAGES 10, 9, 6, AND 5



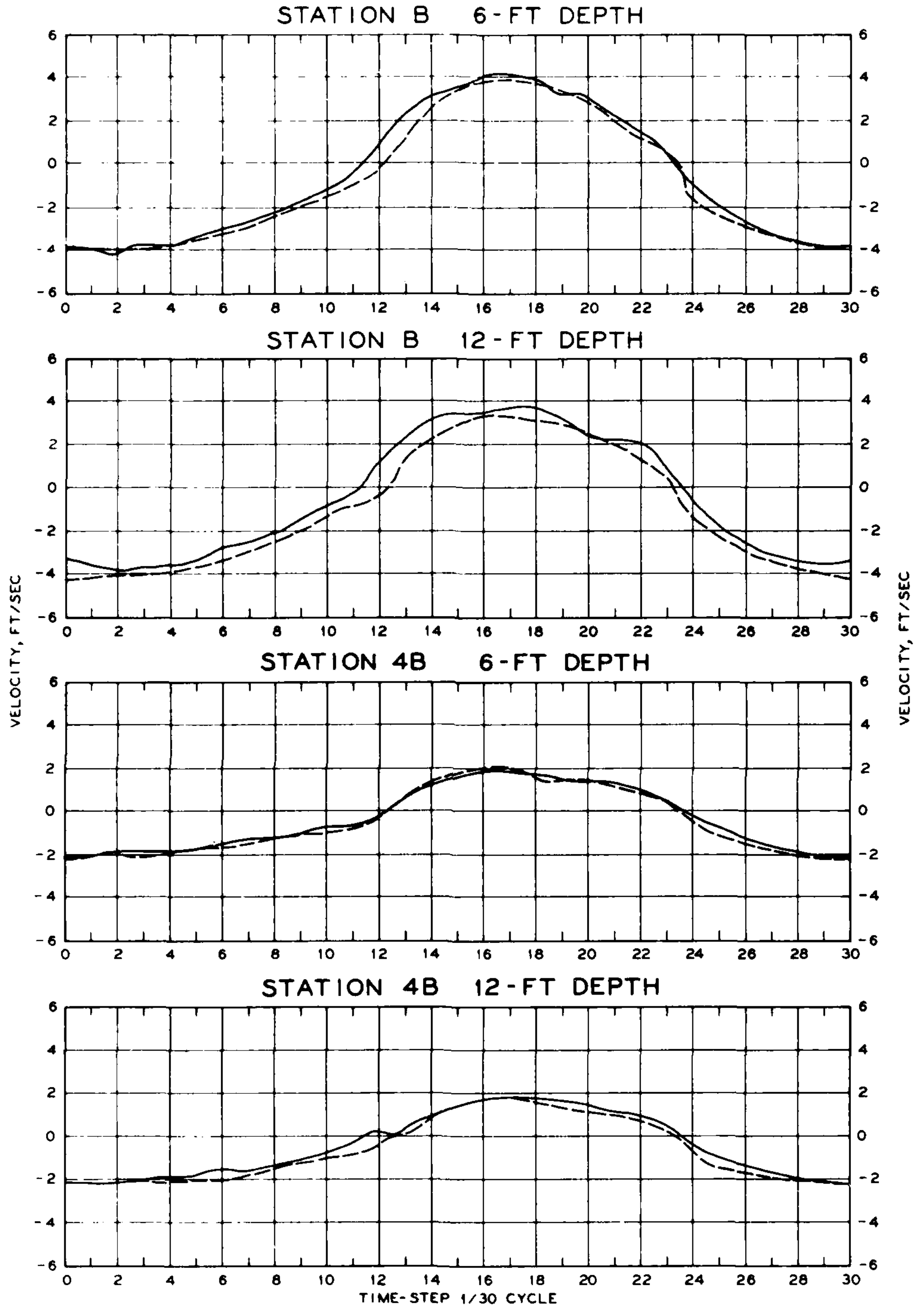
BOTTOM PROTECTION TEST
TIDAL HEIGHTS
TEST 22 VS 24
GAGES 11, 12, 1, AND 3



BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 22 VS 24
STATIONS 1 AND 3

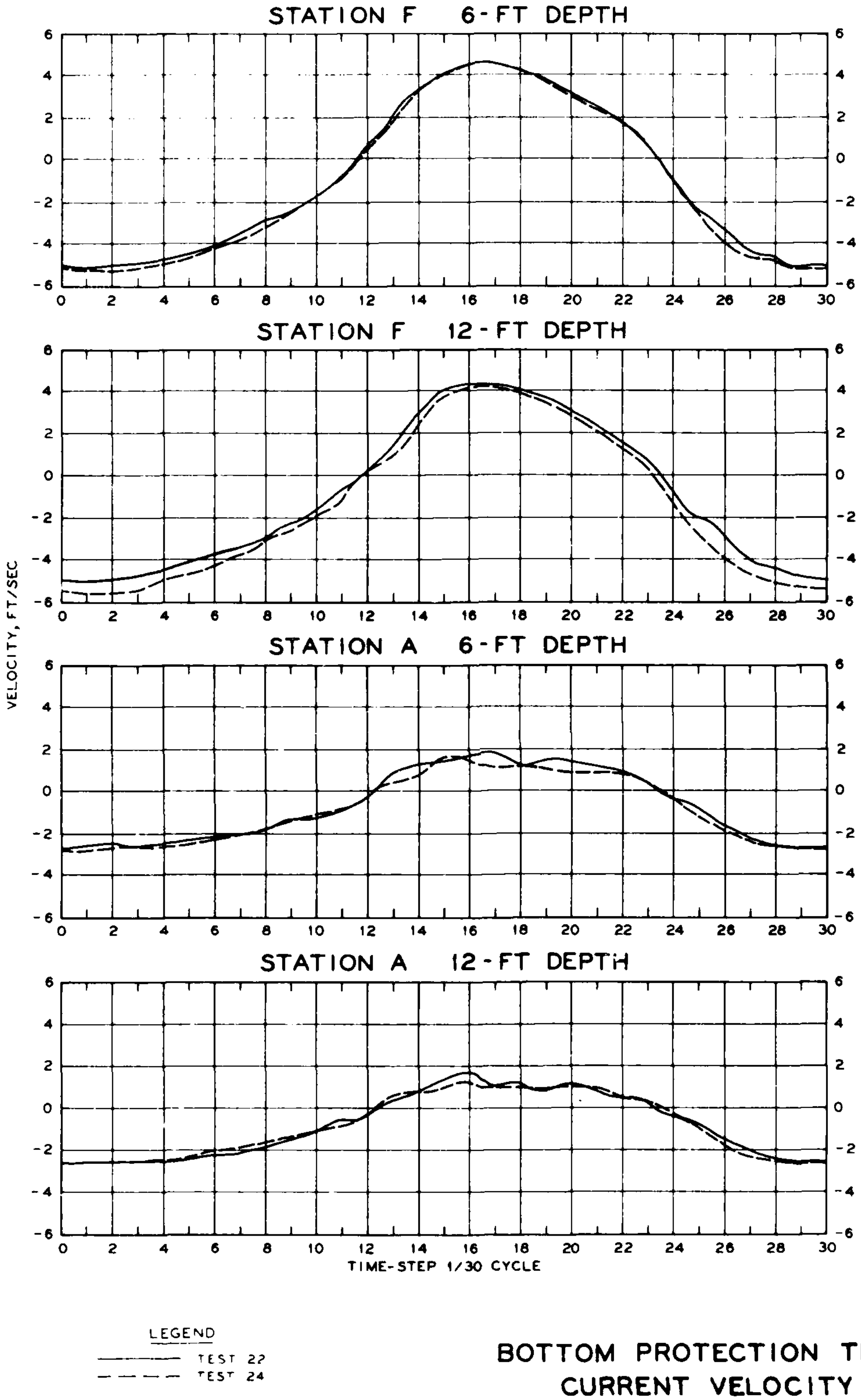


BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 22 VS 24
STATION 2

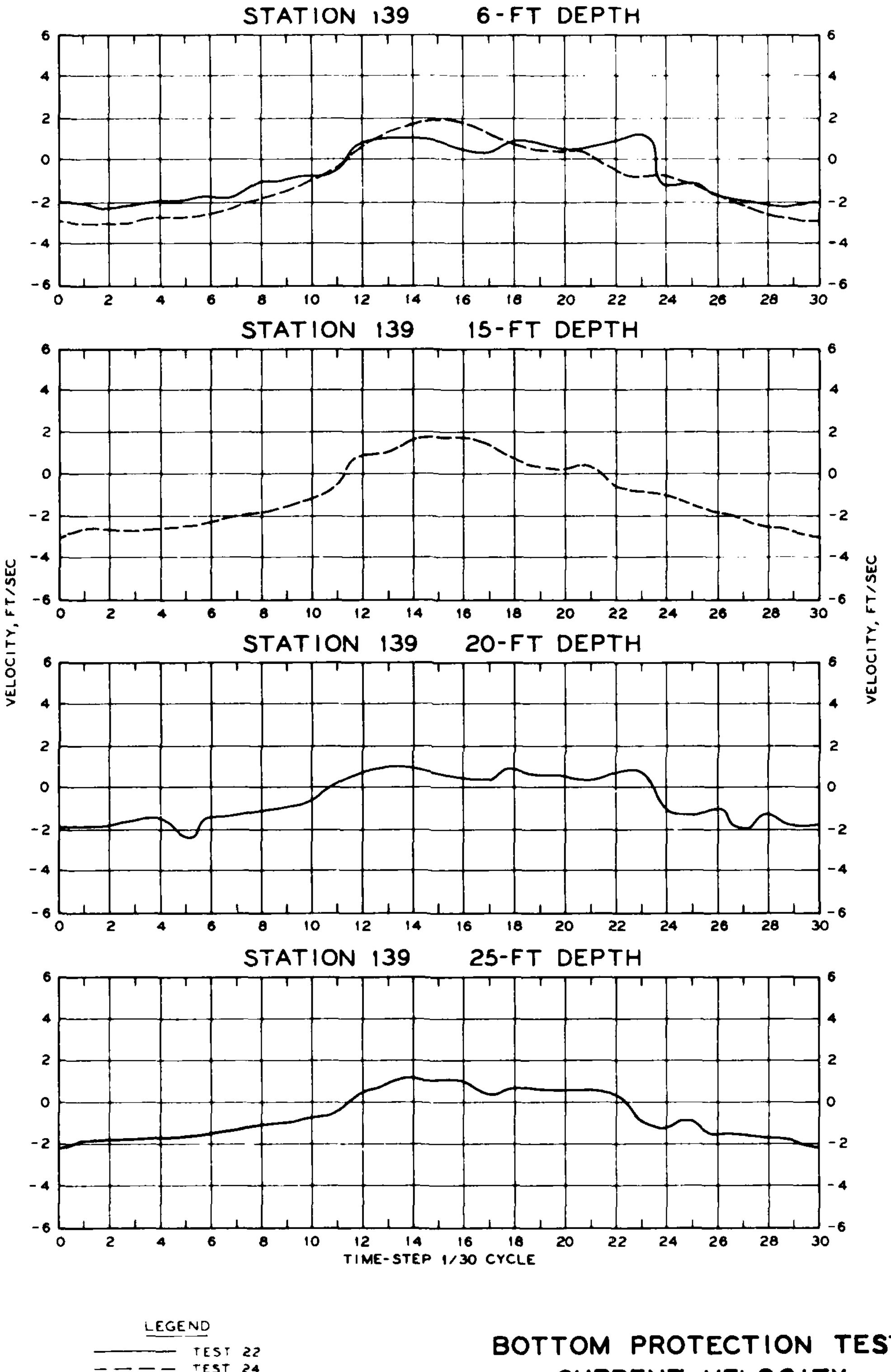


LEGEND
TEST 22
TEST 24

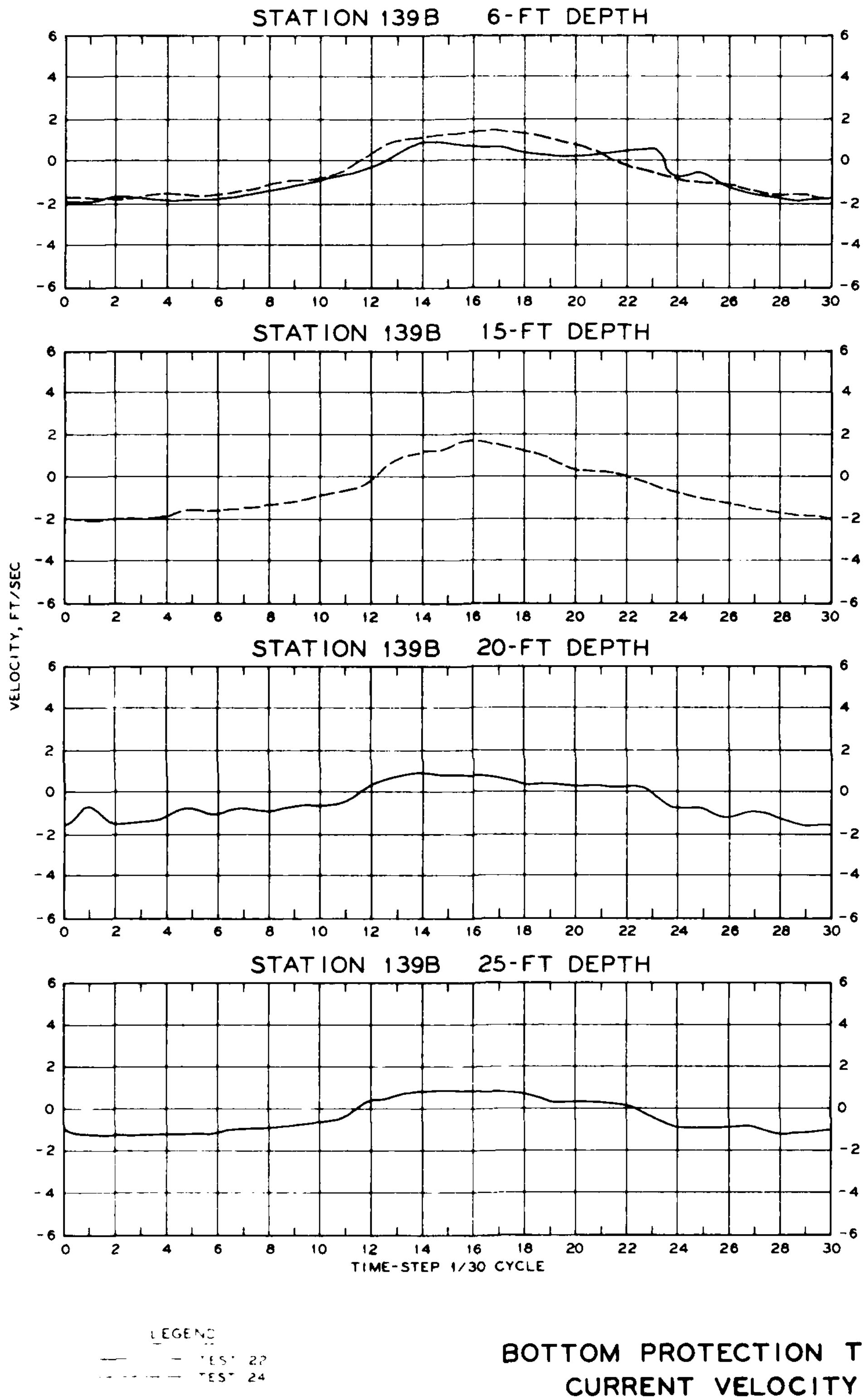
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 22 VS 24
STATIONS 4B AND B



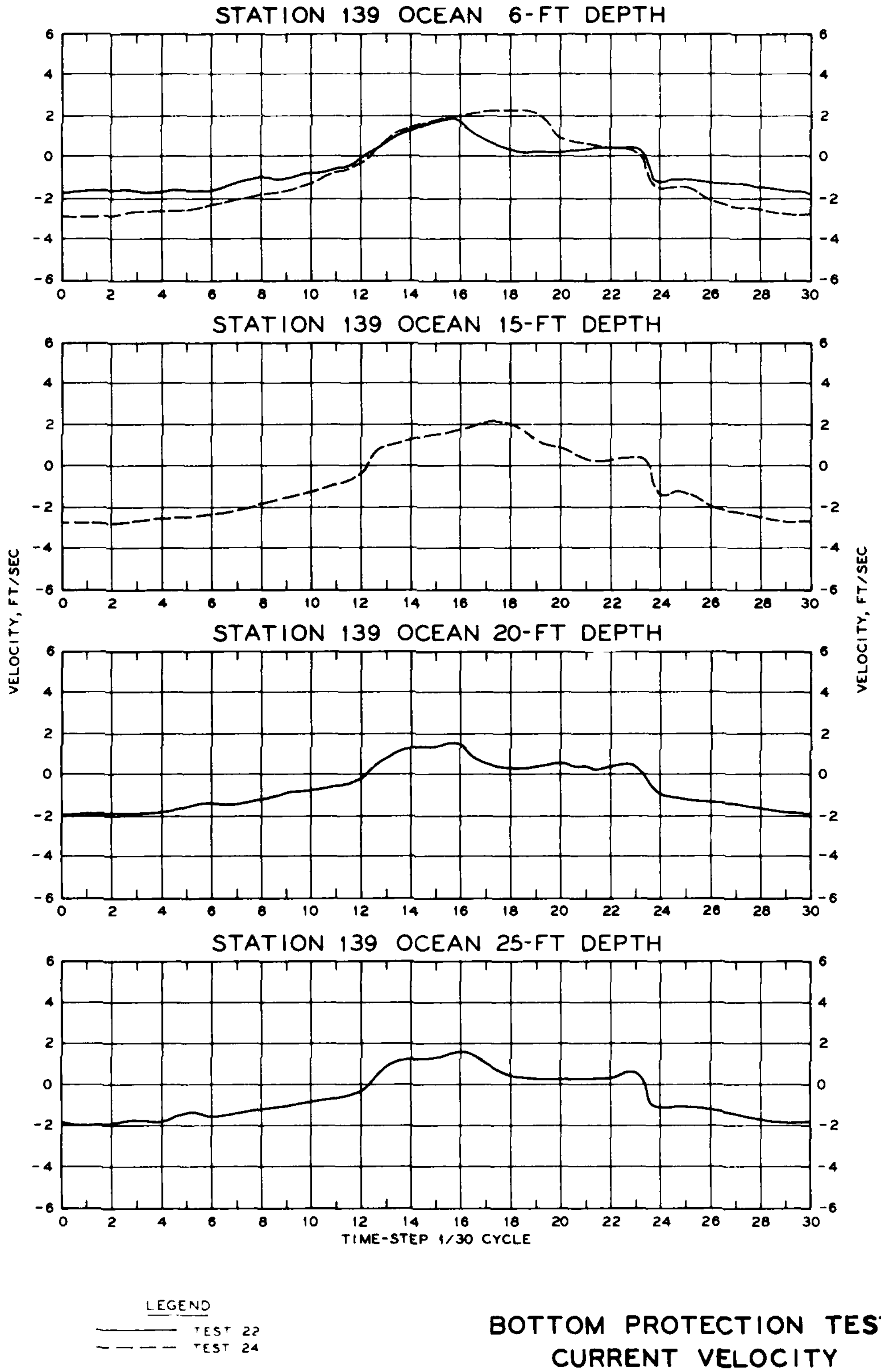
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 22 VS 24
STATIONS F AND A



BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 22 VS 24
STATION 139

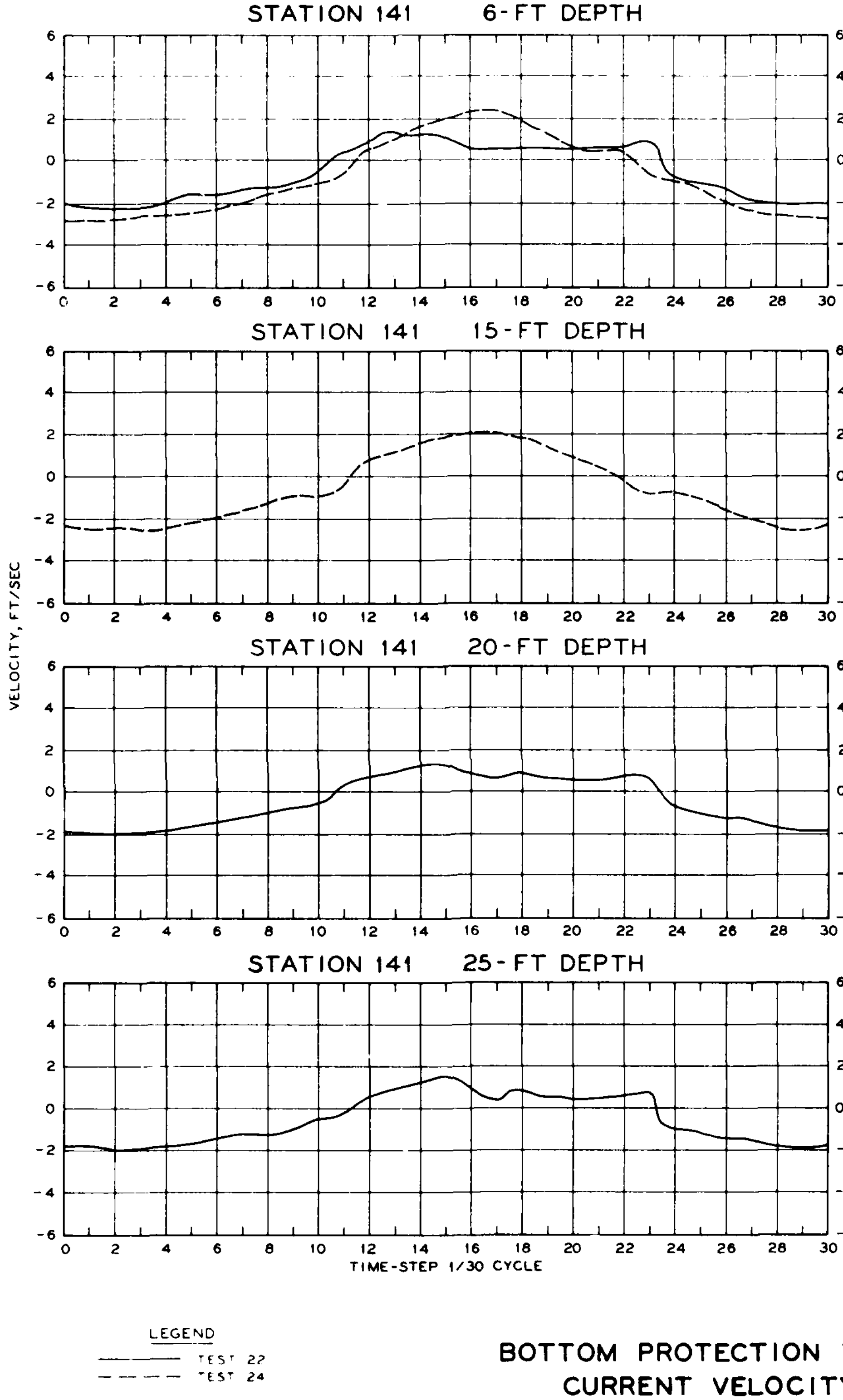


BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 22 VS 24
STATION 139B

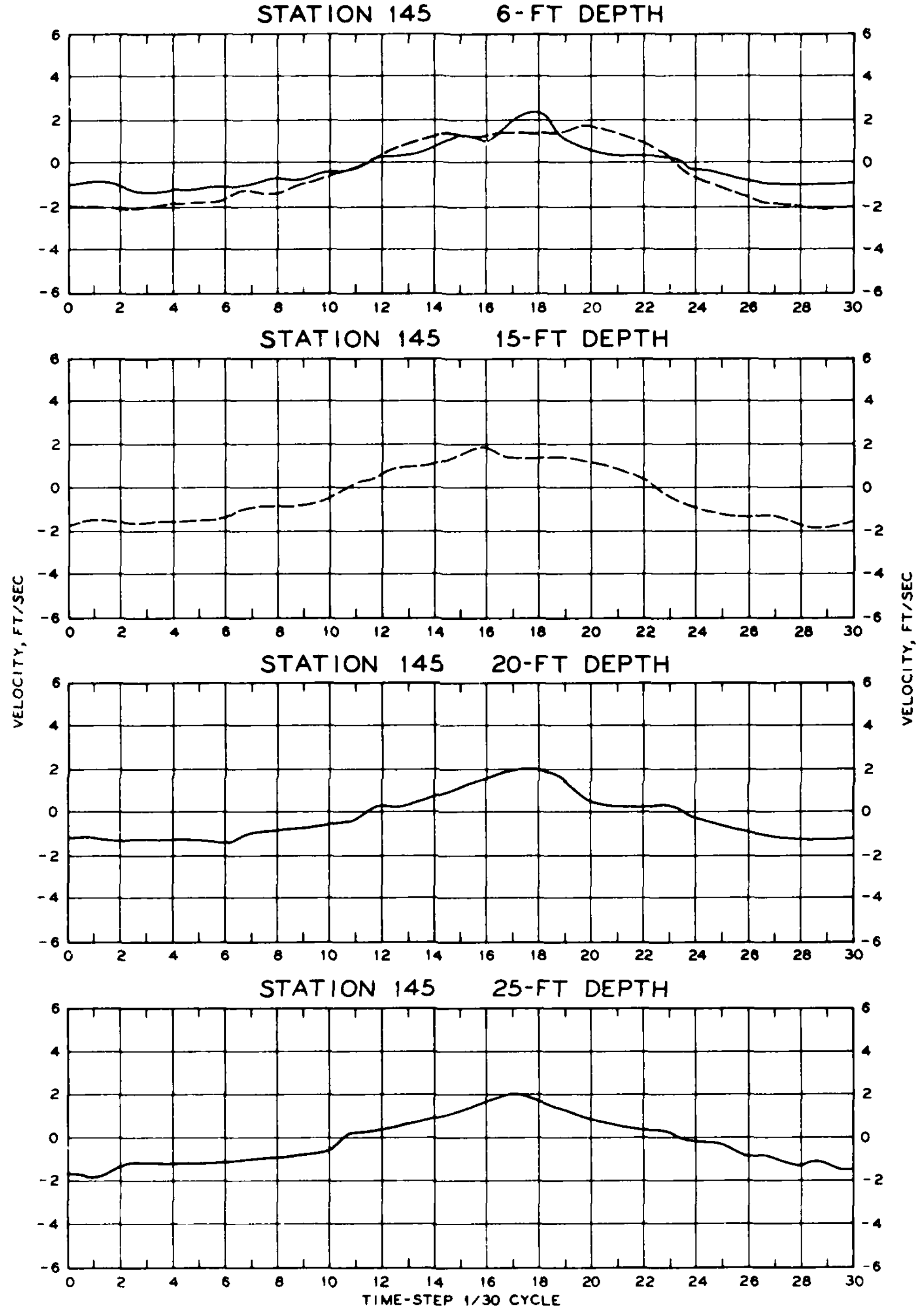


BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 22 VS 24
STATION 139 OCEAN

PLATE 256

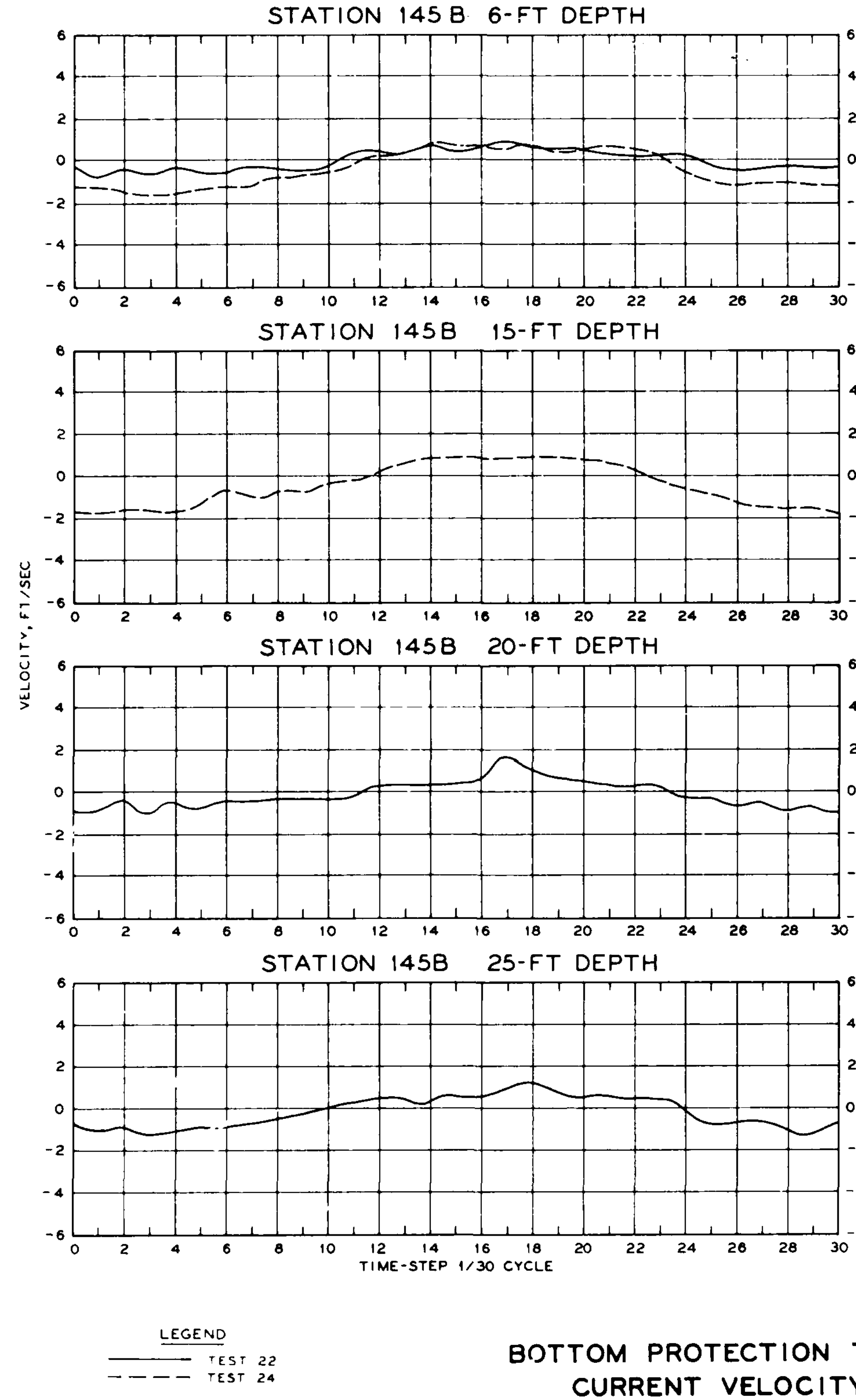


BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 22 VS 24
STATION 141

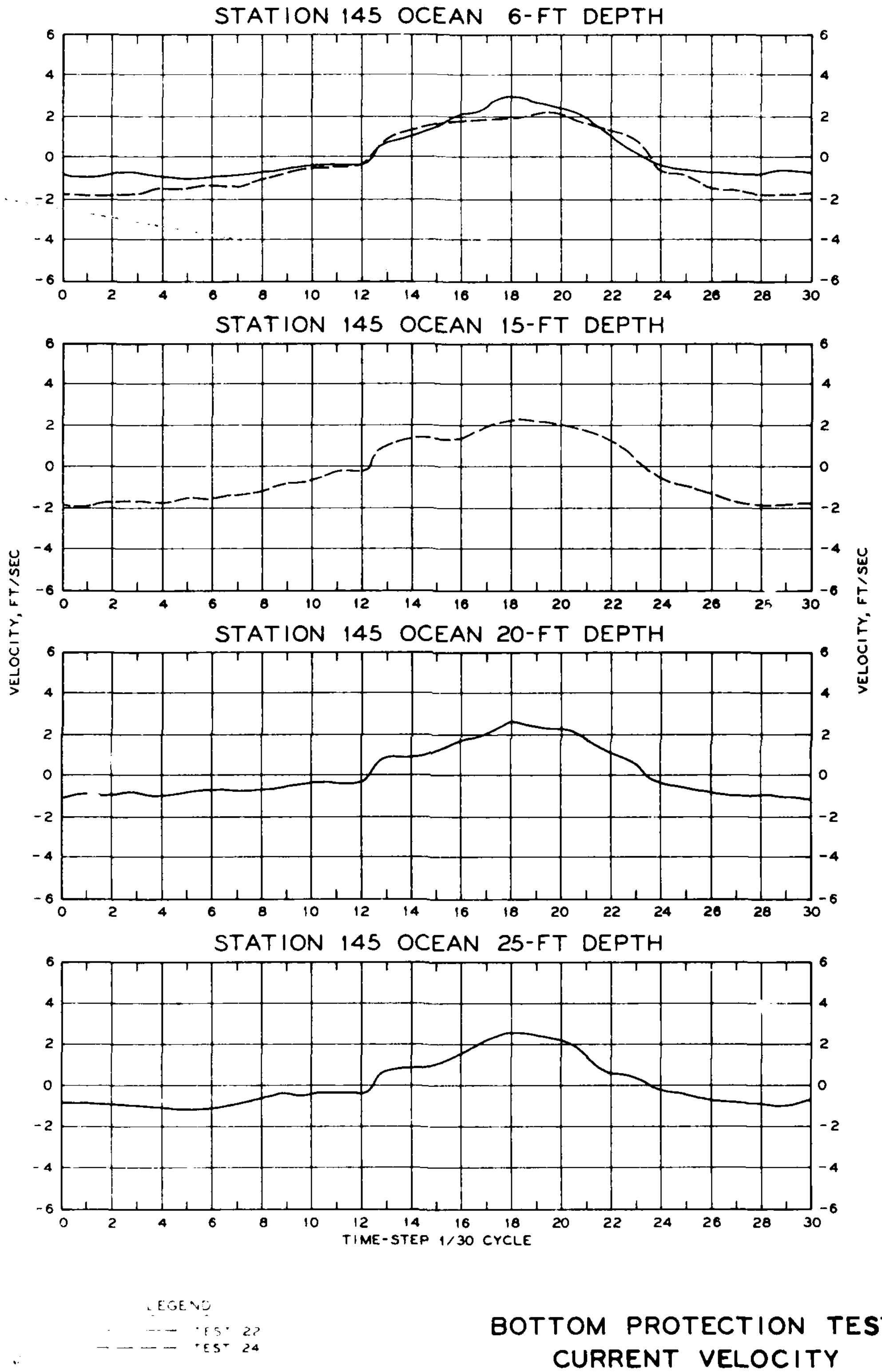


LEGEND
——— TEST 22
— — — TEST 24

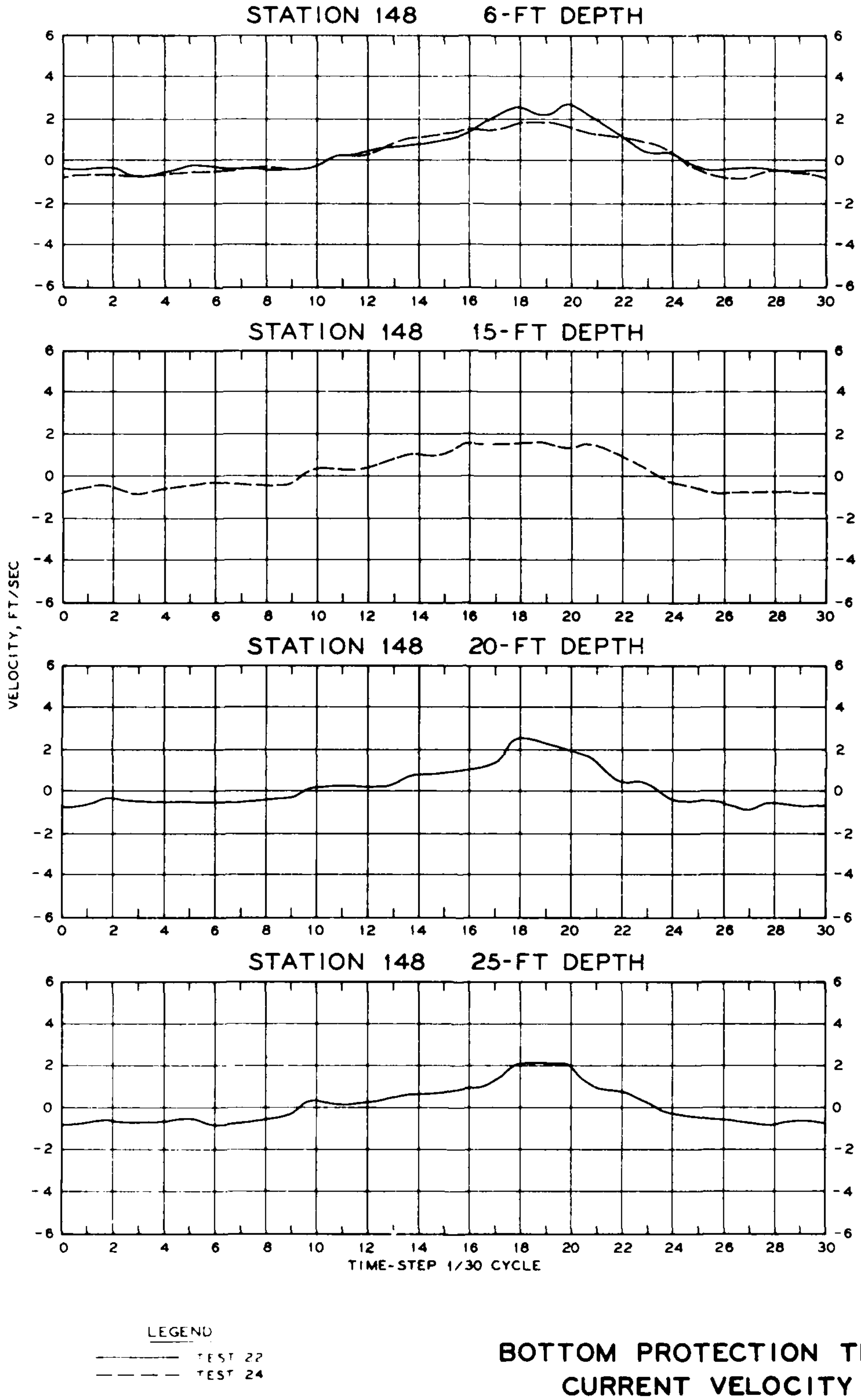
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 22 VS 24
STATION 145



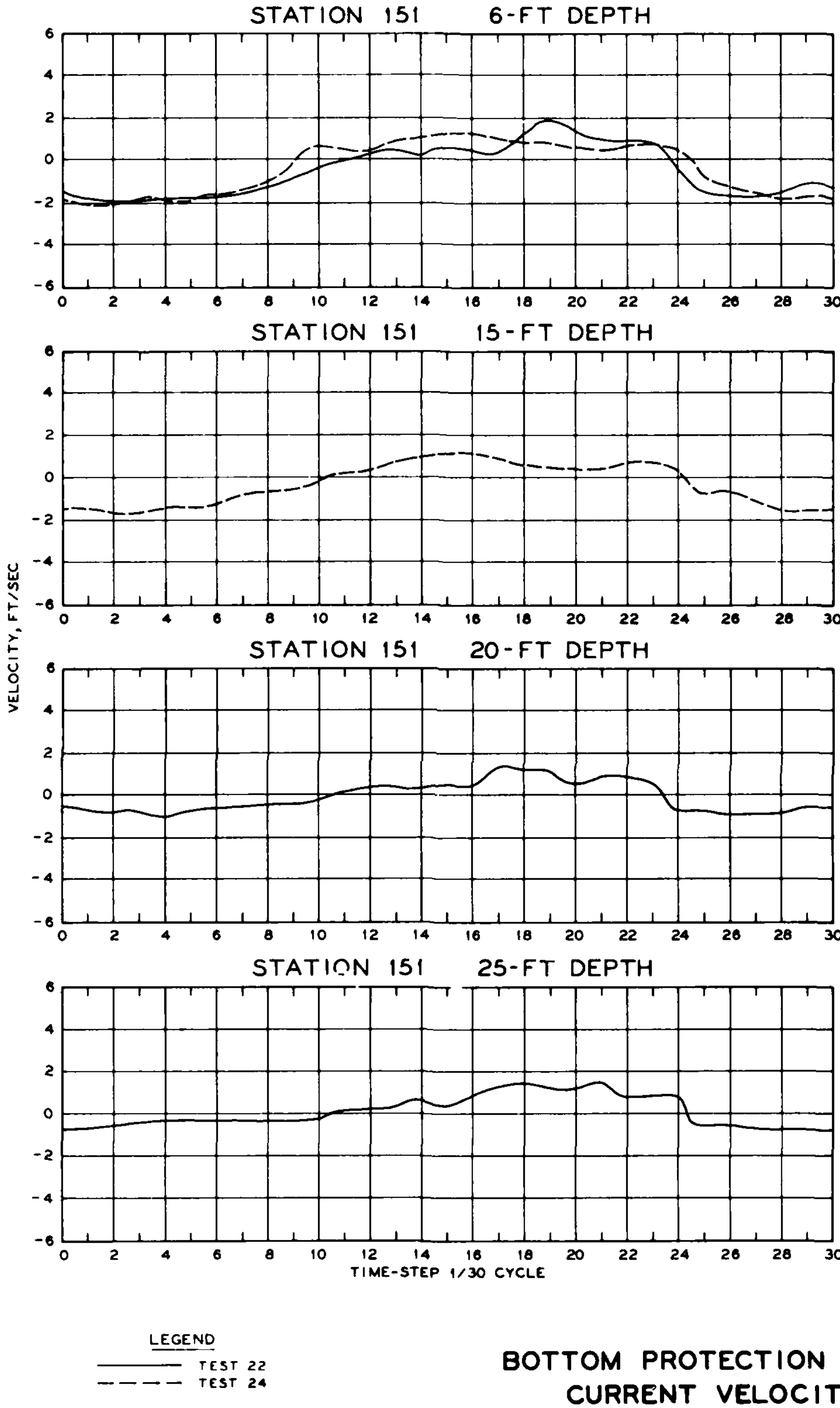
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 22 VS 24
STATION 145B



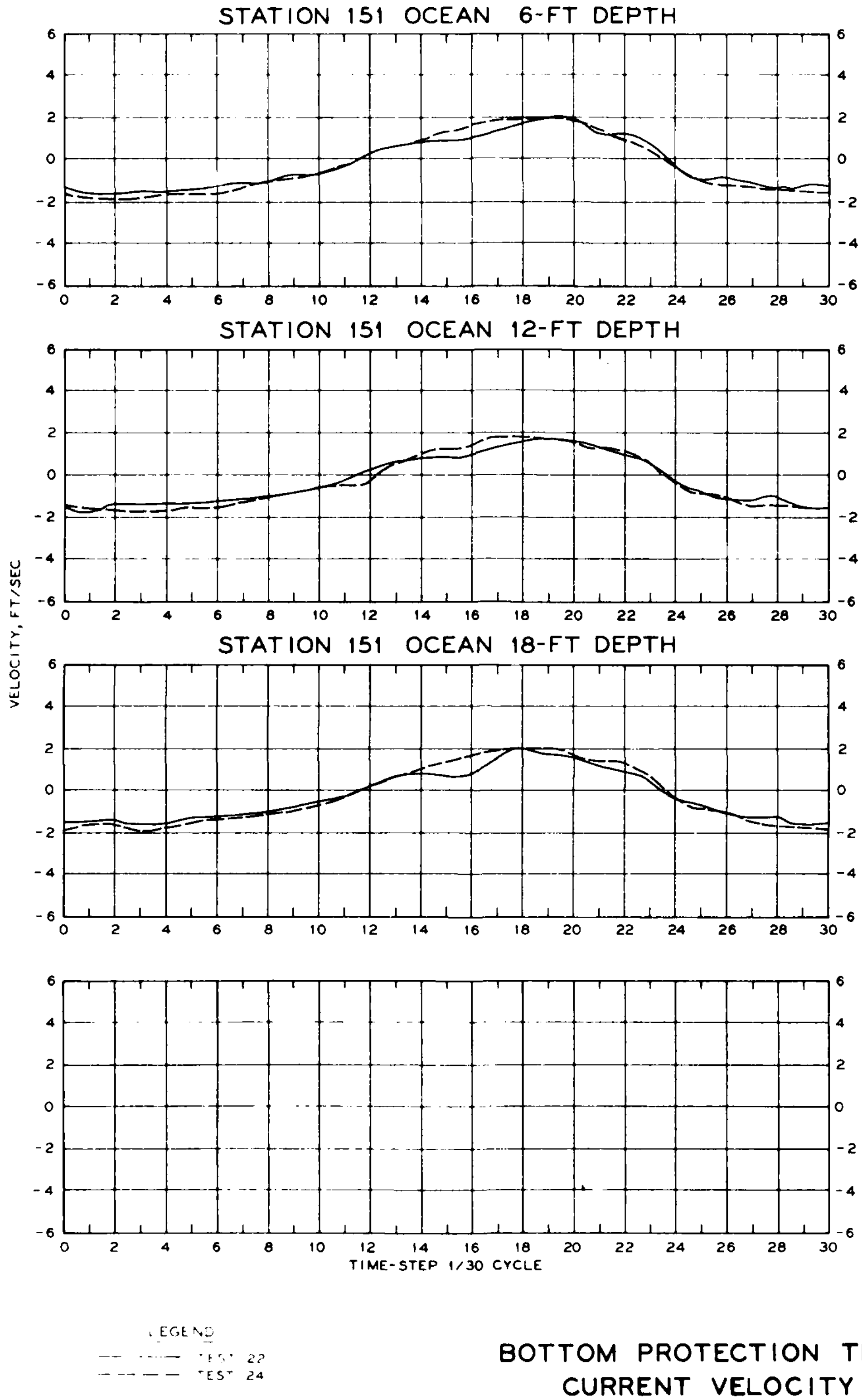
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 22 VS 24
STATION 145 OCEAN



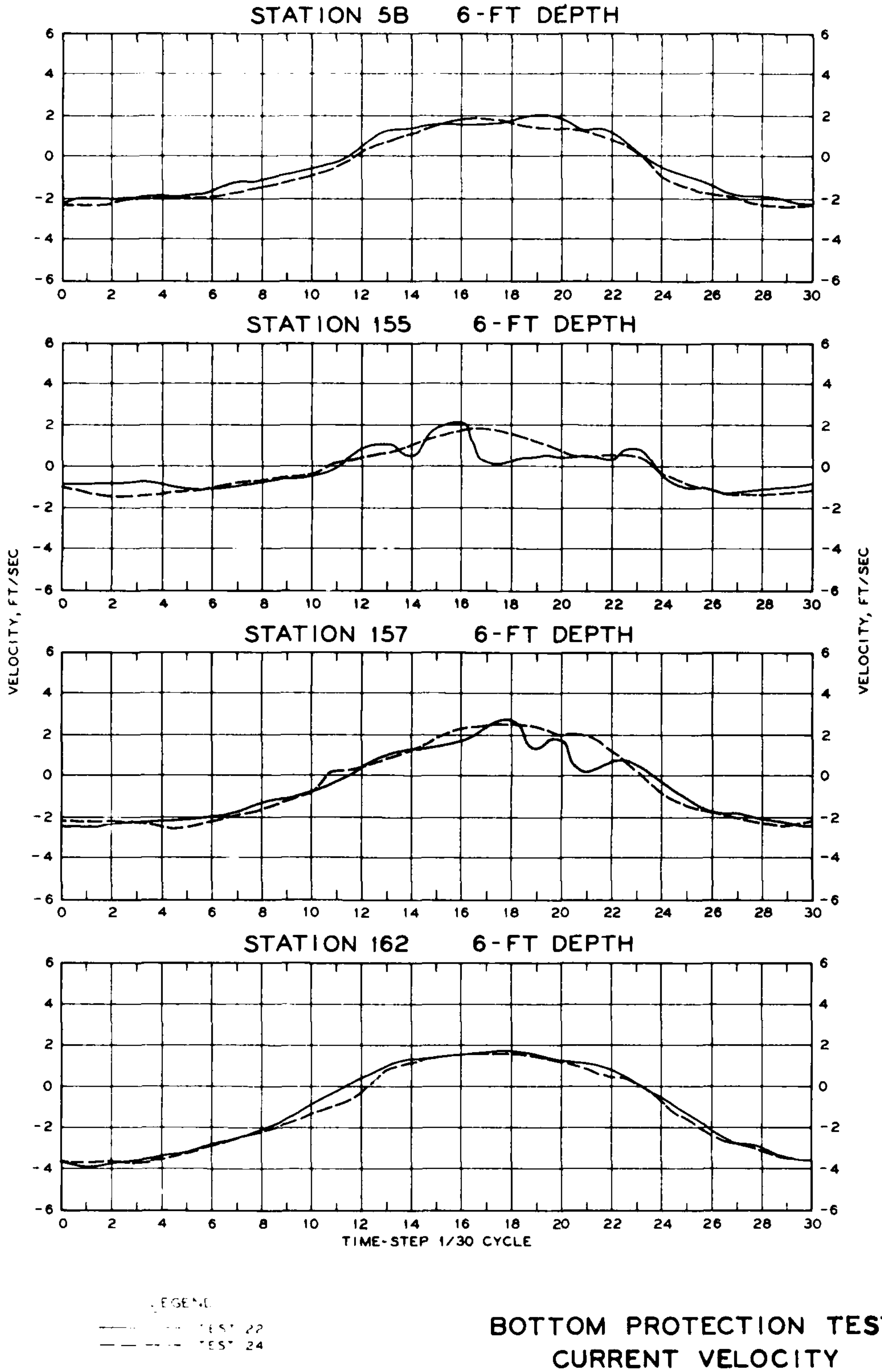
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 22 VS 24
STATION 148



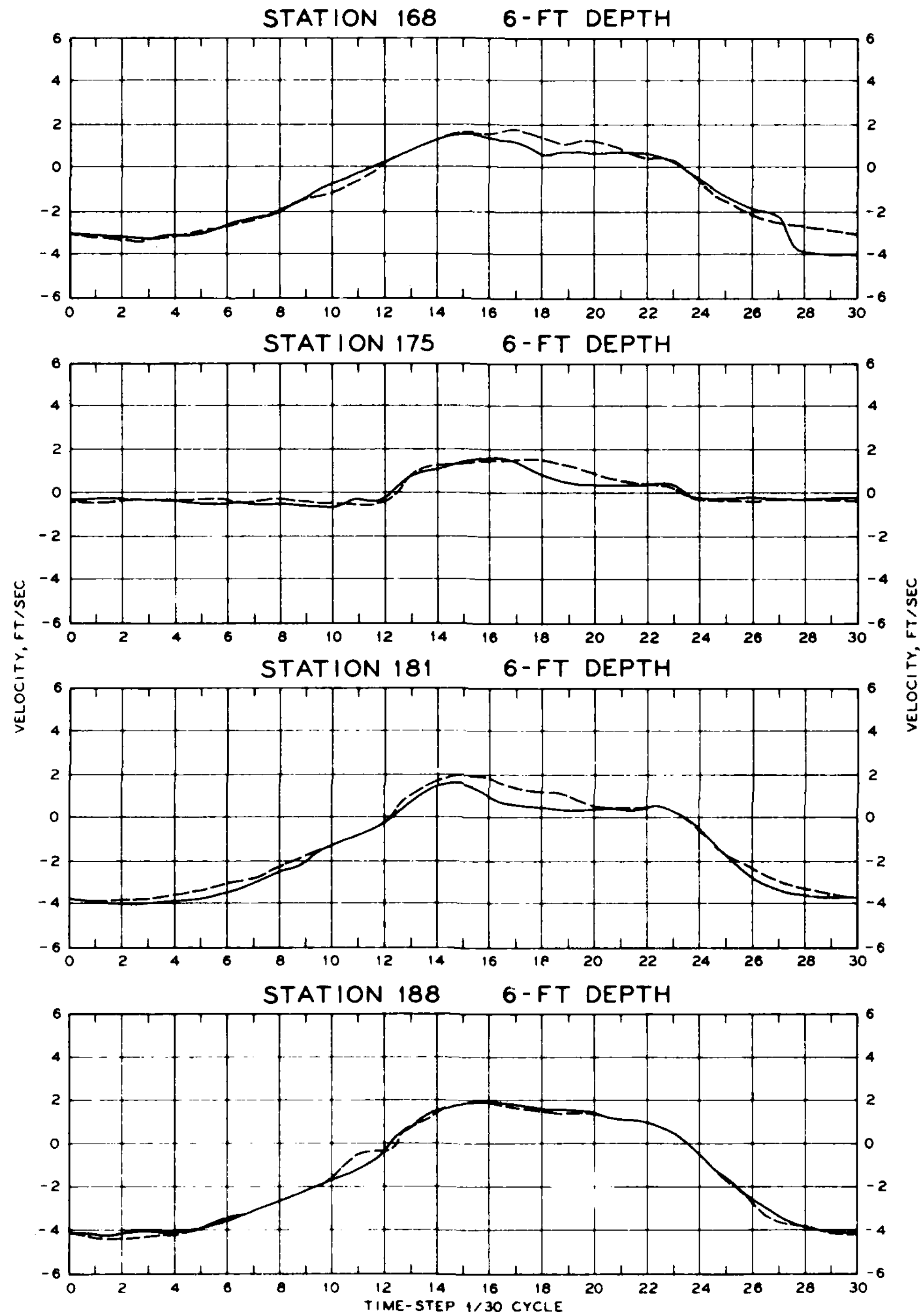
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 22 VS 24
STATION 151



BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 22 VS 24
STATIONS 151 OCEAN AND 5B

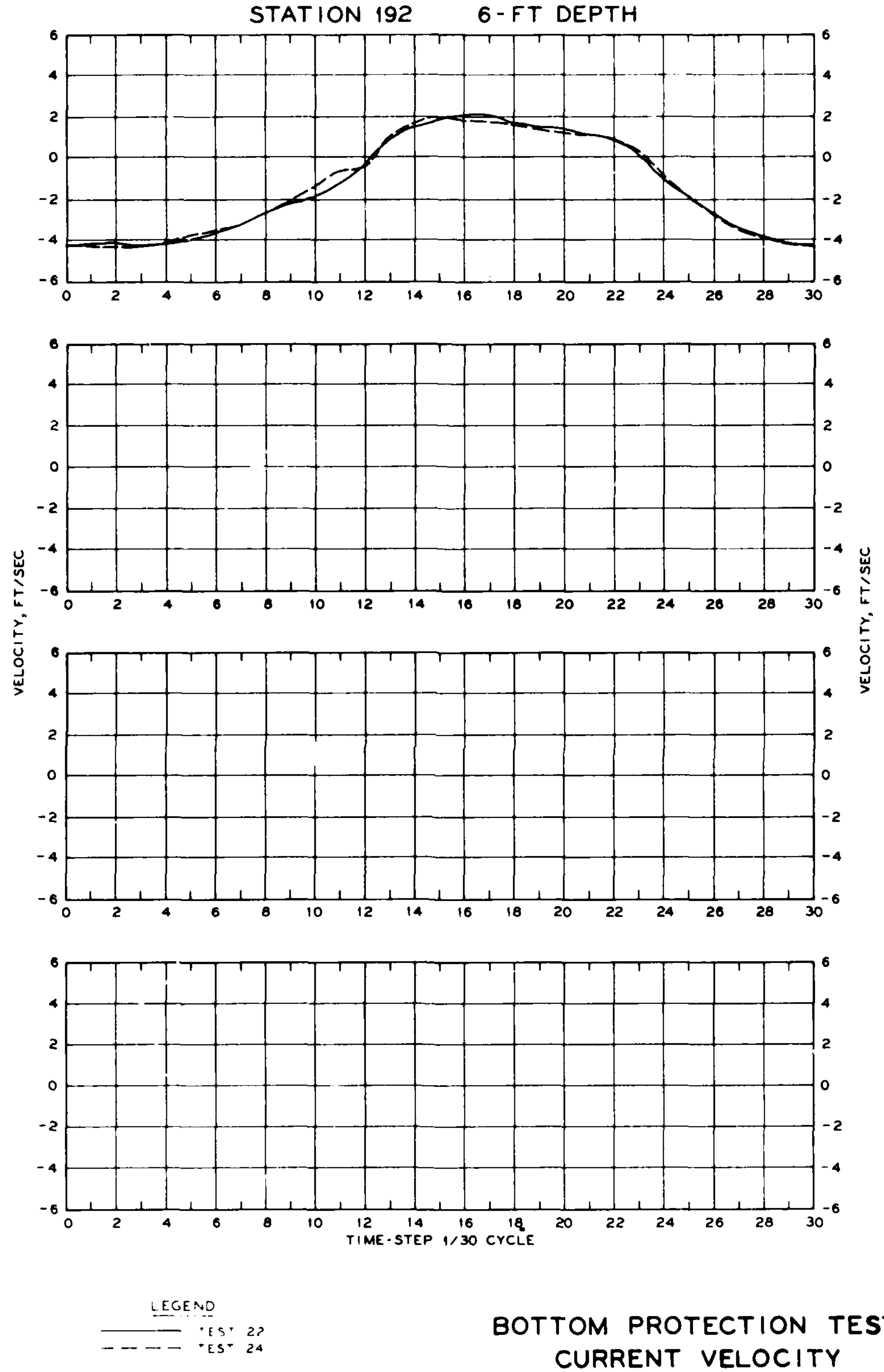


BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 22 VS 24
STATIONS 5B, 155, 157, AND 162

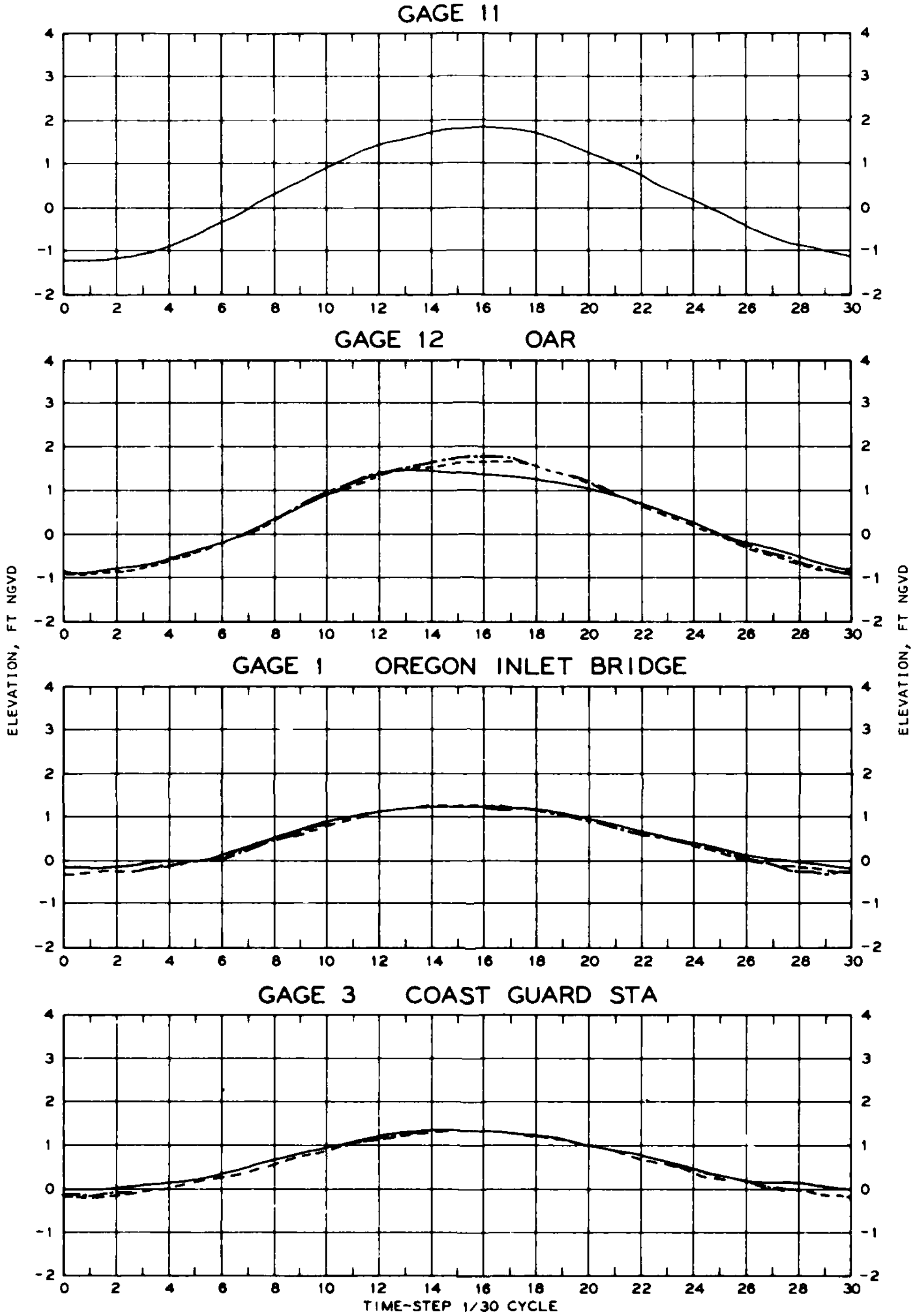


LEGEND
—— TEST 22
– – – TEST 24

BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 22 VS 24
STATIONS 168, 175, 181, AND 188



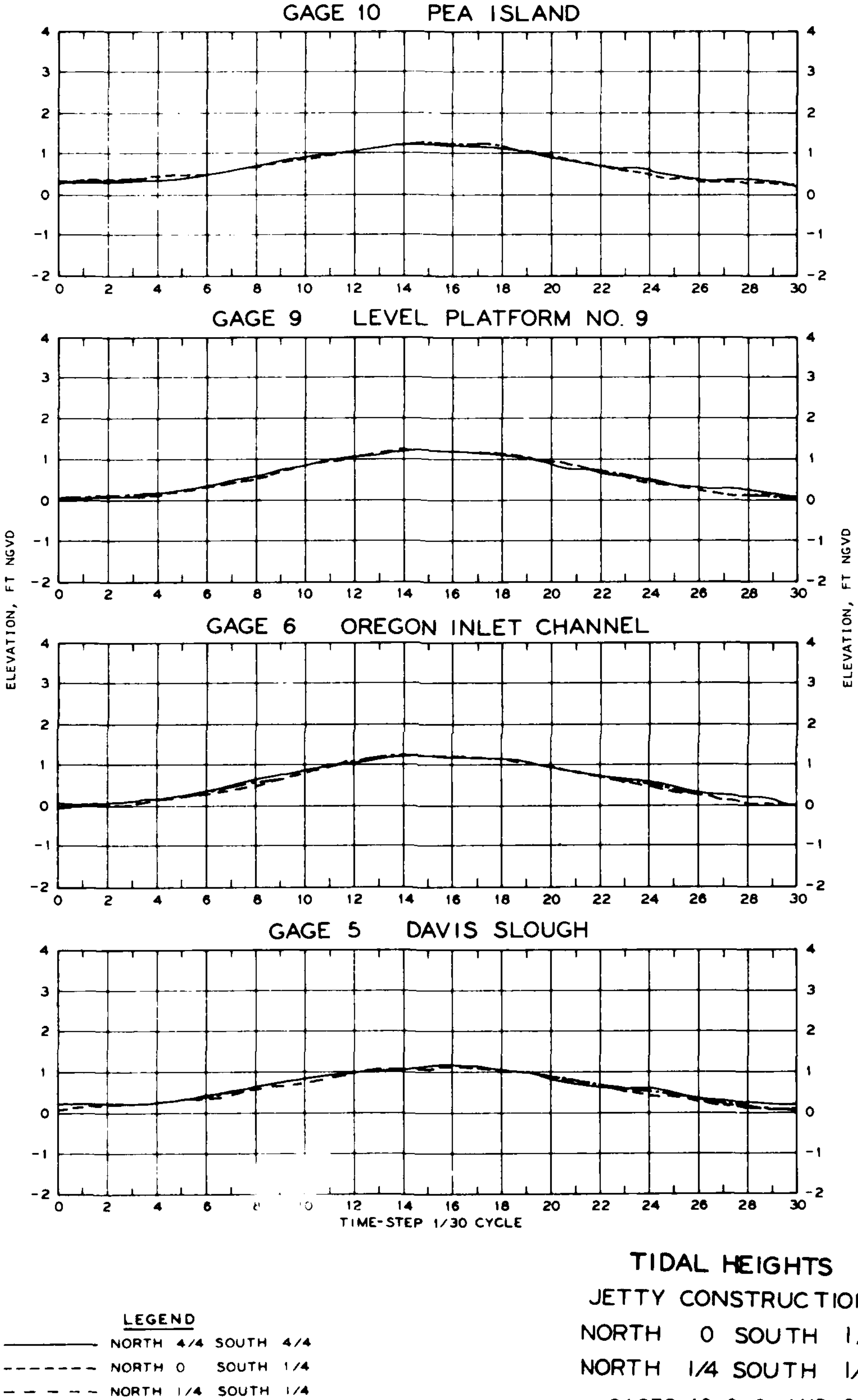
BOTTOM PROTECTION TEST
CURRENT VELOCITY
TEST 22 VS 24
STATION 192



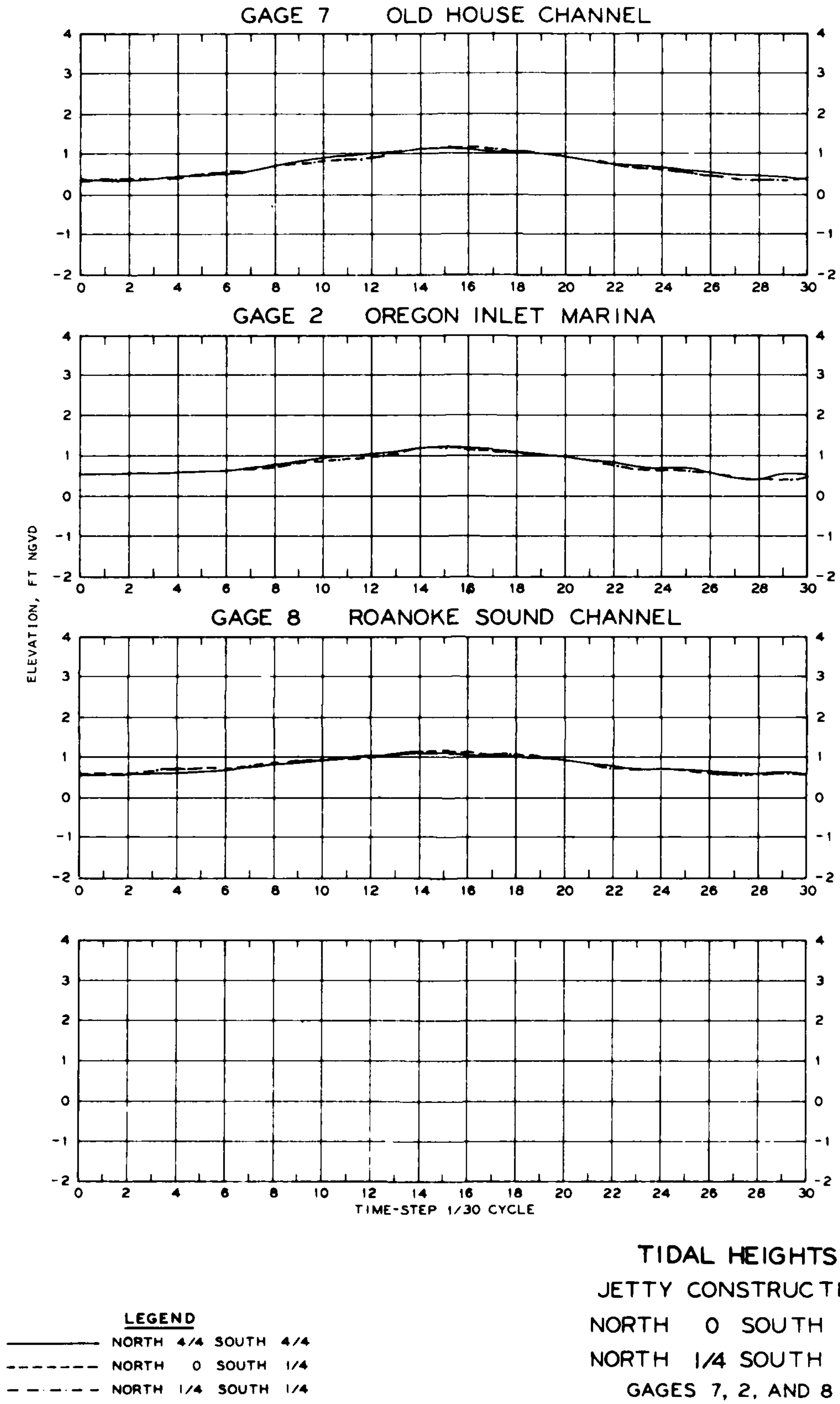
LEGEND

- ———— NORTH 4/4 SOUTH 4/4
- - - - - - NORTH 0 SOUTH 1/4
- —·—·— NORTH 1/4 SOUTH 1/4

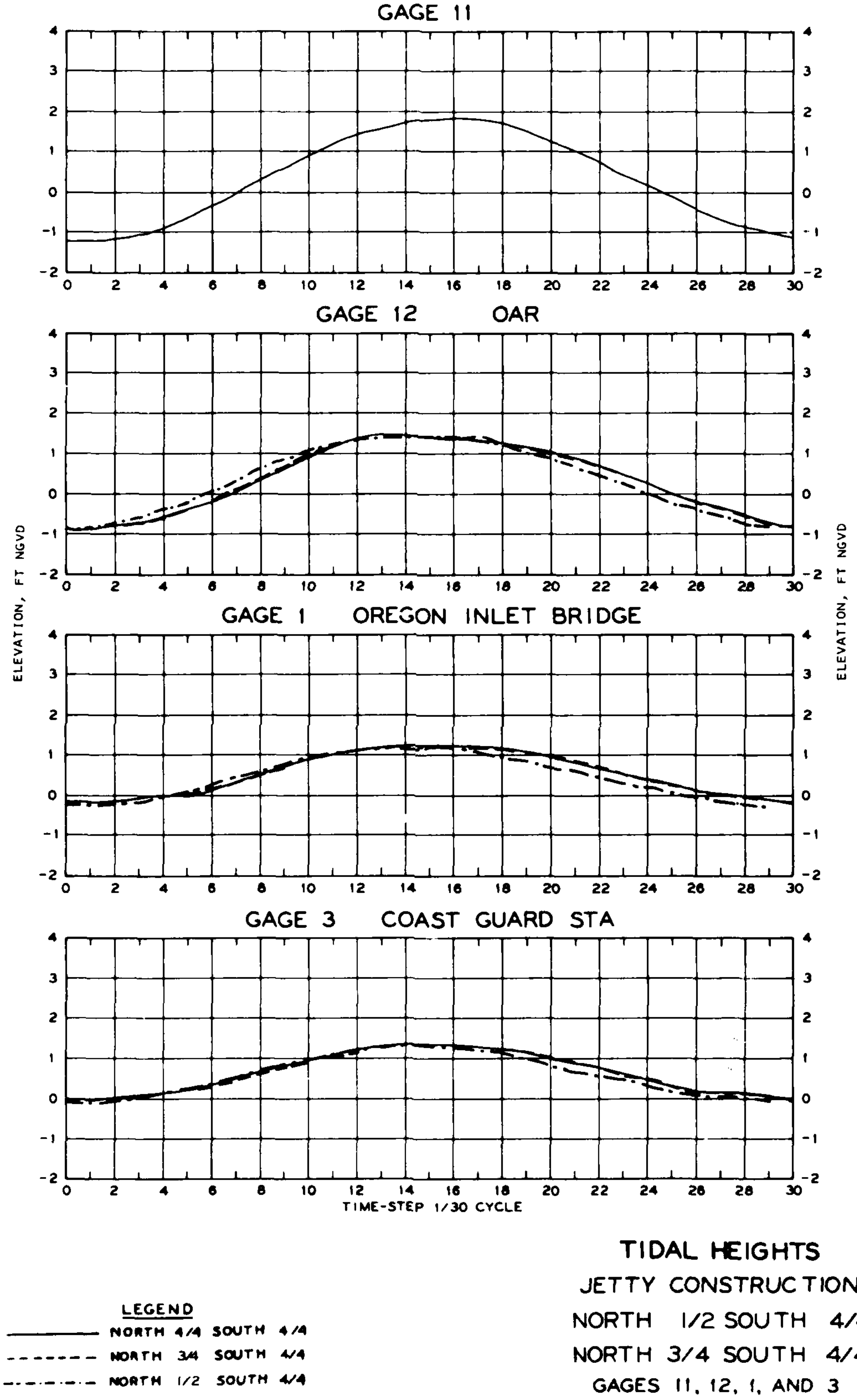
TIDAL HEIGHTS
JETTY CONSTRUCTION
NORTH 0 SOUTH 1/4
NORTH 1/4 SOUTH 1/4
GAGES 11, 12, 1, AND 3



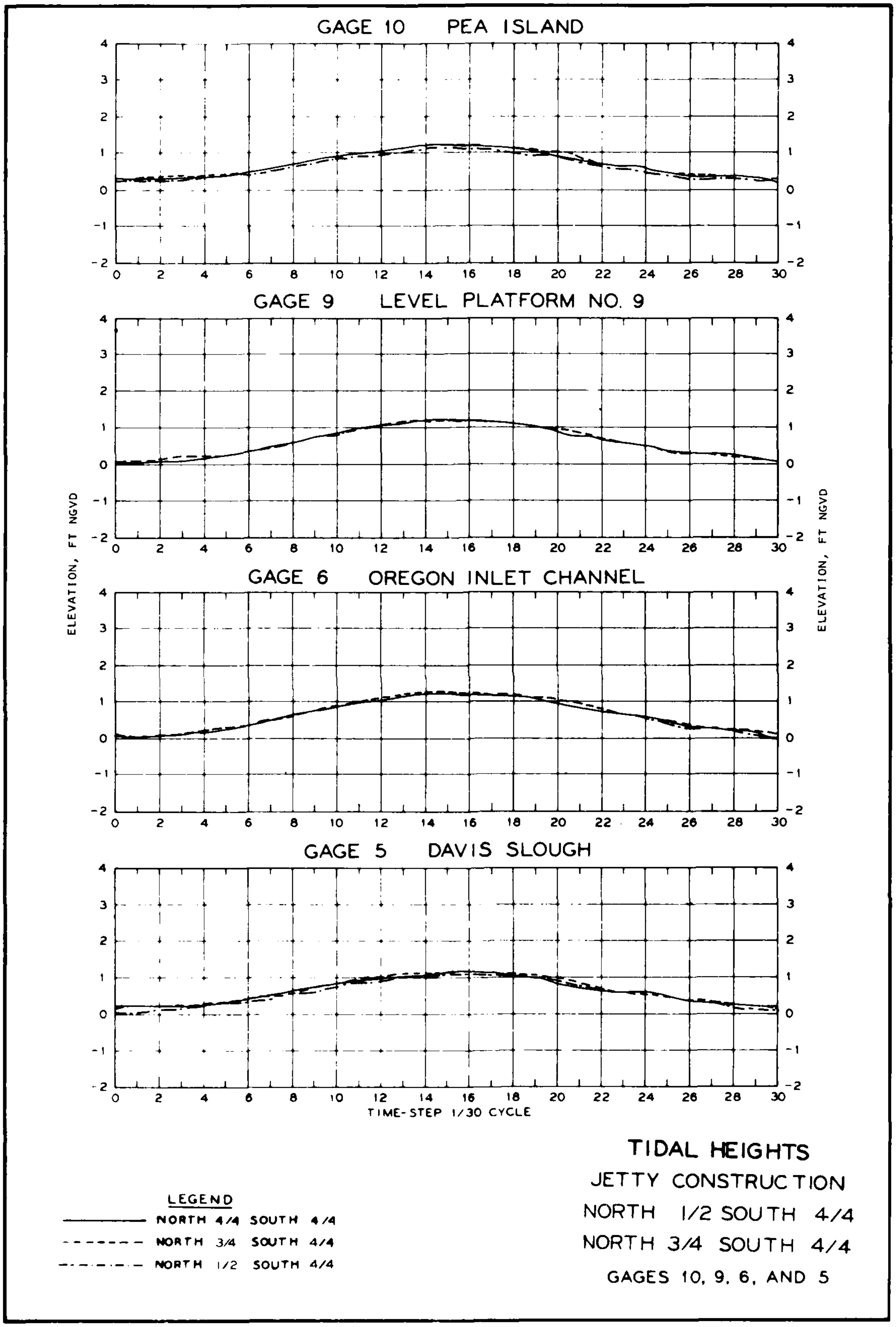
TIDAL HEIGHTS
JETTY CONSTRUCTION
NORTH 0 SOUTH 1/4
NORTH 1/4 SOUTH 1/4
GAGES 10, 9, 6, AND 5



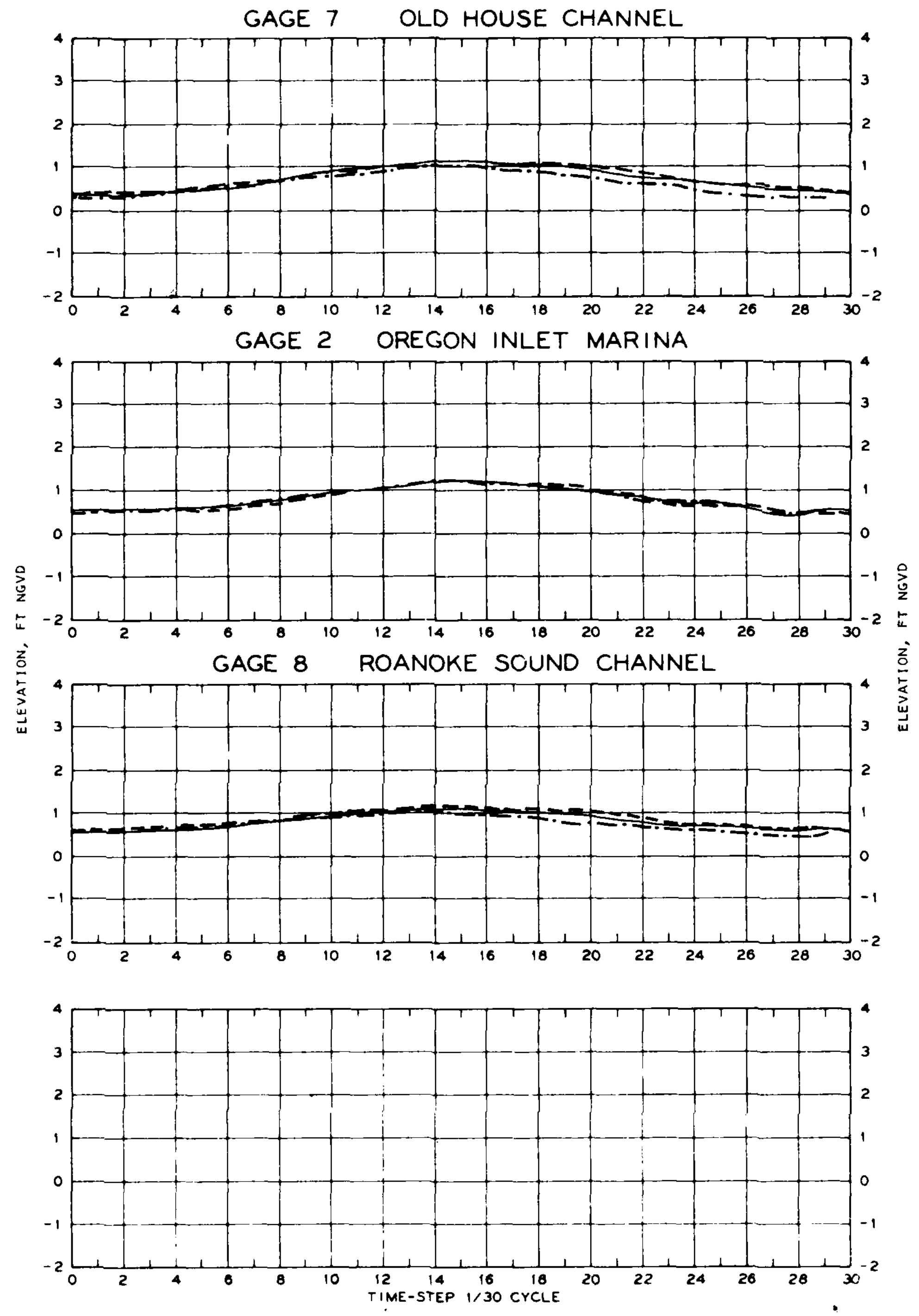
TIDAL HEIGHTS
JETTY CONSTRUCTION
NORTH 0 SOUTH 1/4
NORTH 1/4 SOUTH 1/4
GAGES 7, 2, AND 8



TIDAL HEIGHTS
JETTY CONSTRUCTION
NORTH 1/2 SOUTH 4/4
NORTH 3/4 SOUTH 4/4
GAGES 11, 12, 1, AND 3



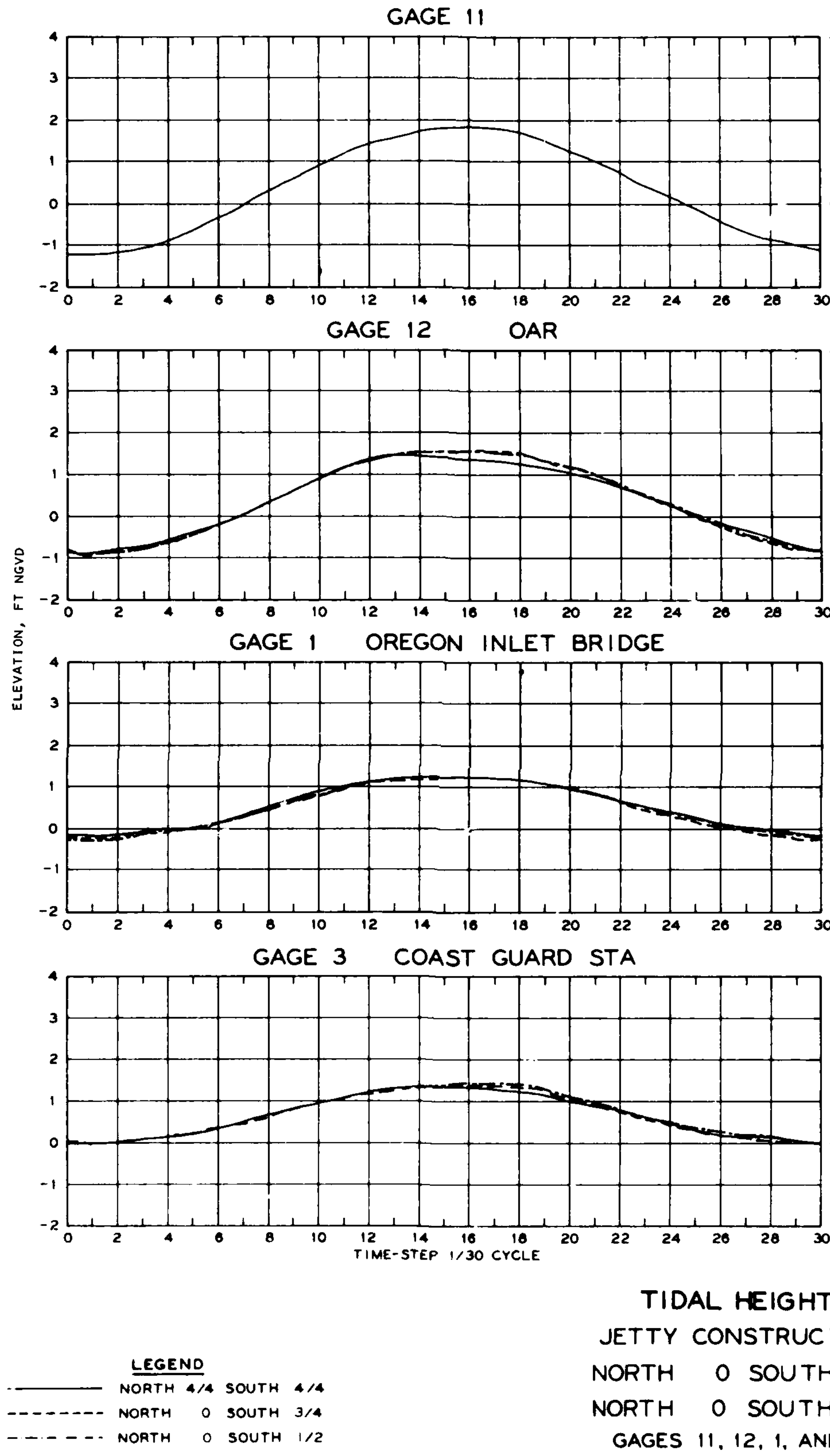
GAGE 10 PEA ISLAND
GAGE 9 LEVEL PLATFORM NO. 9
GAGE 6 OREGON INLET CHANNEL
GAGE 5 DAVIS SLOUGH
ELEVATION, FT NGVD
TIME-STEP 1/30 CYCLE
LEGEND
NORTH 4/4 SOUTH 4/4
NORTH 3/4 SOUTH 4/4
NORTH 1/2 SOUTH 4/4
TIDAL HEIGHTS
JETTY CONSTRUCTION
NORTH 1/2 SOUTH 4/4
NORTH 3/4 SOUTH 4/4
GAGES 10, 9, 6, AND 5



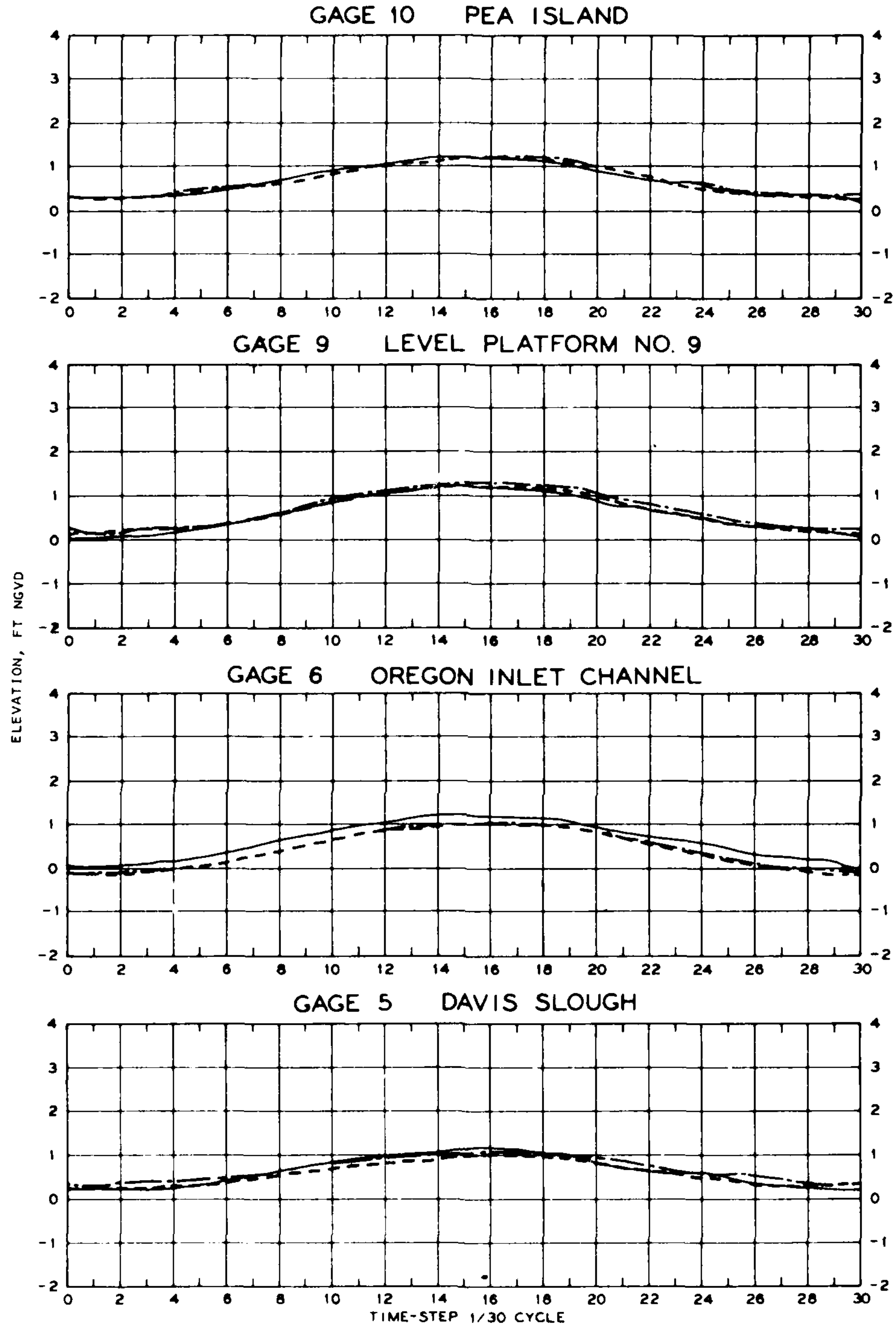
LEGEND

- ——— NORTH 4/4 SOUTH 4/4
- - - - - NORTH 3/4 SOUTH 4/4
- -·-·-· NORTH 1/2 SOUTH 4/4

TIDAL HEIGHTS
JETTY CONSTRUCTION
NORTH 1/2 SOUTH 4/4
NORTH 3/4 SOUTH 4/4
GAGES 7, 2, AND 8



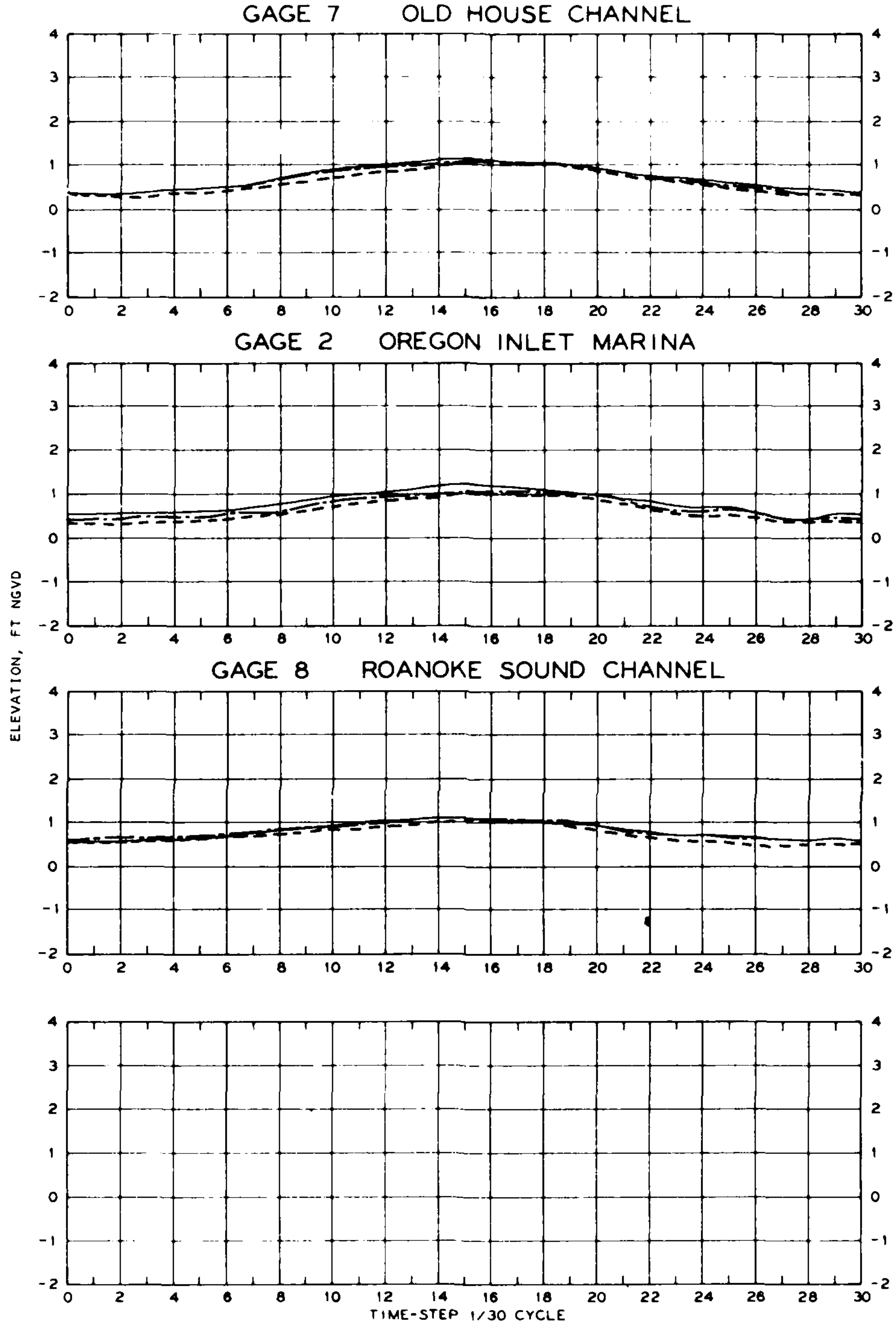
TIDAL HEIGHTS
JETTY CONSTRUCTION
NORTH 0 SOUTH 1/2
NORTH 0 SOUTH 3/4
GAGES 11, 12, 1, AND 3



LEGEND

————	NORTH 4/4 SOUTH 4/4
------	NORTH 0 SOUTH 1/2
— - — - —	NORTH 0 SOUTH 3/4

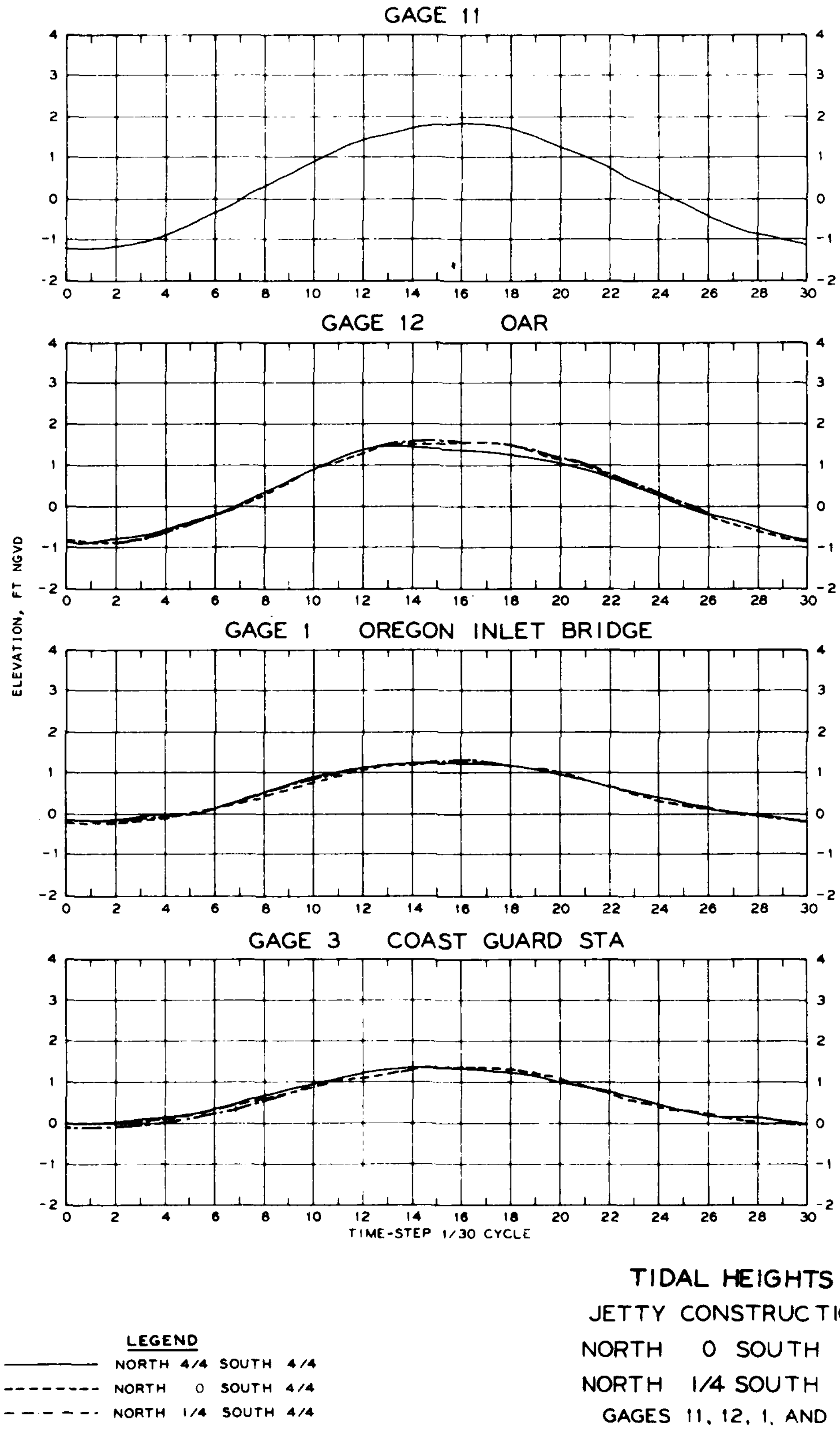
TIDAL HEIGHTS
JETTY CONSTRUCTION
NORTH 0 SOUTH 1/2
NORTH 0 SOUTH 3/4
GAGES 10, 9, 6, AND 5



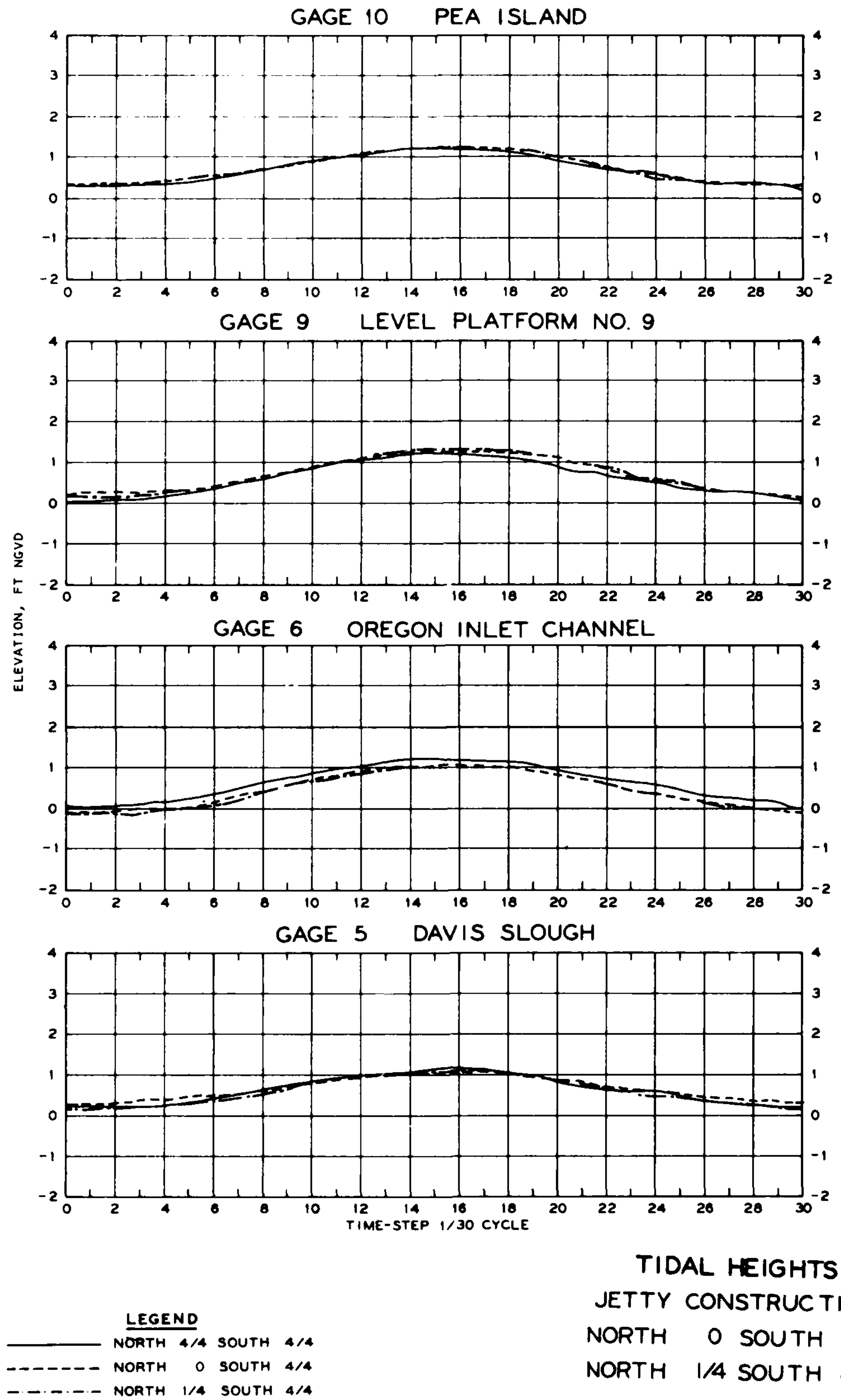
LEGEND

————	NORTH 4/4 SOUTH 4/4
--------	NORTH 0 SOUTH 1/2
– – – – –	NORTH 0 SOUTH 3/4

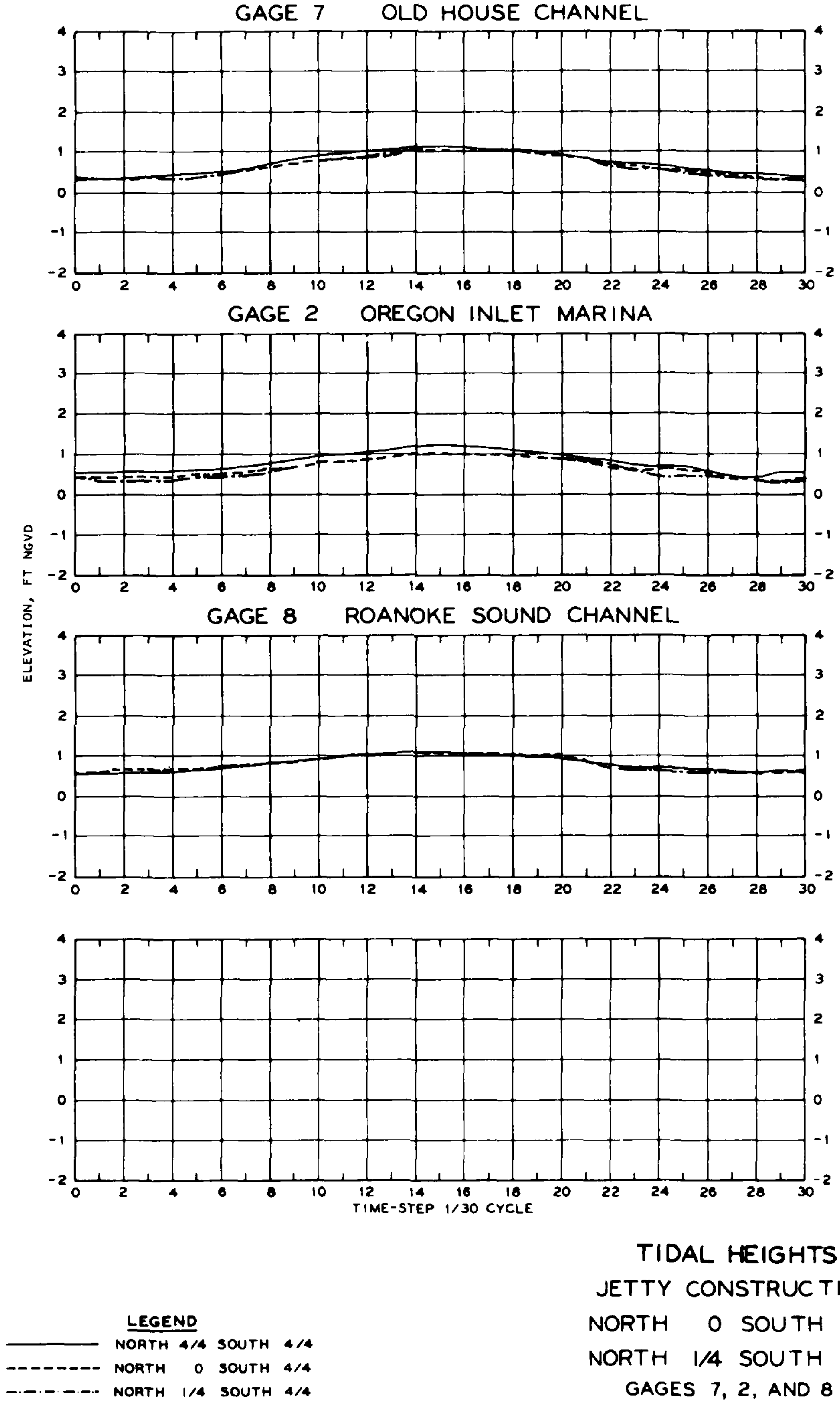
TIDAL HEIGHTS
JETTY CONSTRUCTION
NORTH 0 SOUTH 1/2
NORTH 0 SOUTH 3/4
GAGES 7, 2, AND 8



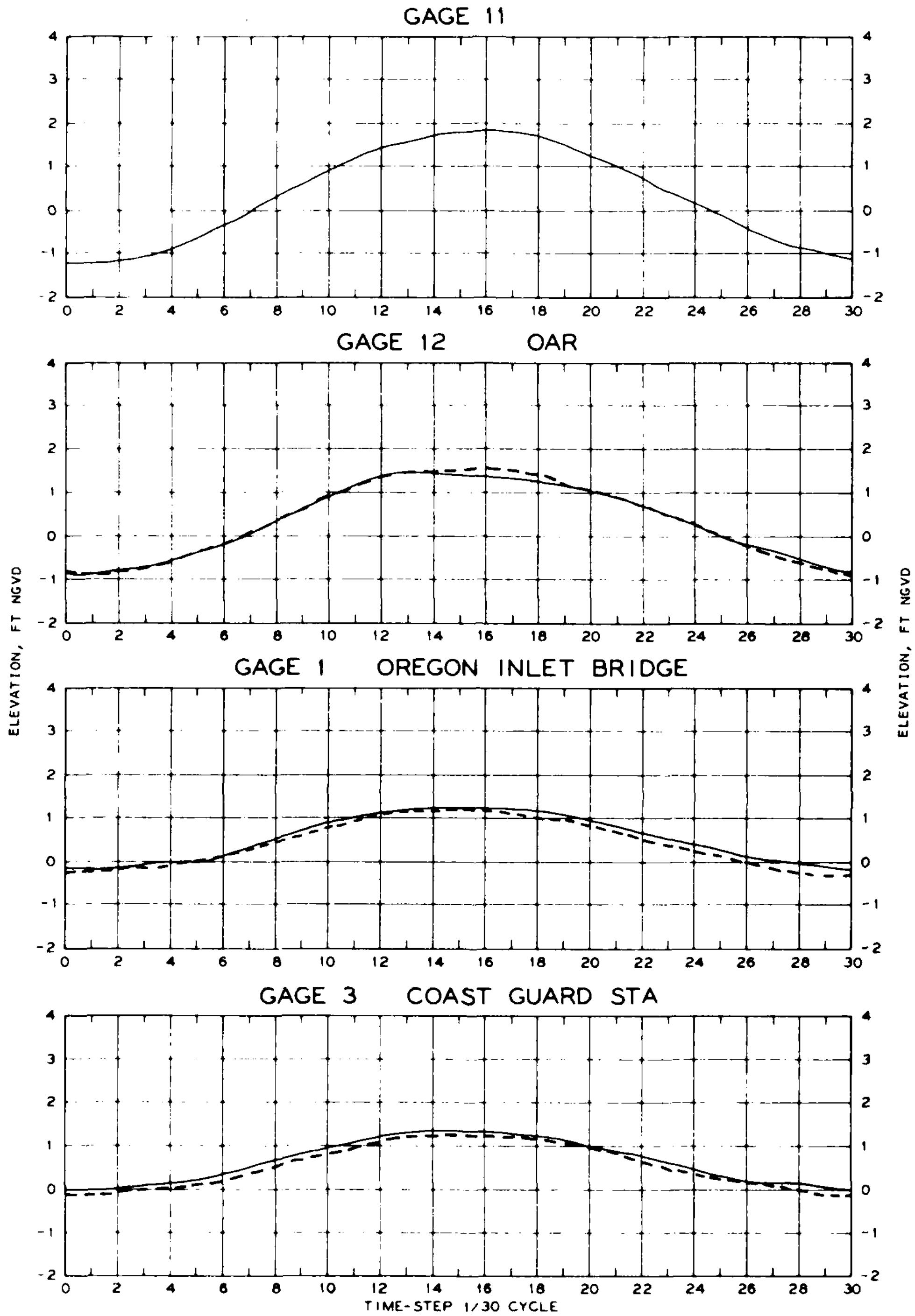
TIDAL HEIGHTS
JETTY CONSTRUCTION
NORTH 0 SOUTH 4/4
NORTH 1/4 SOUTH 4/4
GAGES 11, 12, 1, AND 3



TIDAL HEIGHTS
JETTY CONSTRUCTION
NORTH 0 SOUTH 4/4
NORTH 1/4 SOUTH 4/4
GAGES 10, 9, 6, AND 5



TIDAL HEIGHTS
JETTY CONSTRUCTION
NORTH 0 SOUTH 4/4
NORTH 1/4 SOUTH 4/4
GAGES 7, 2, AND 8

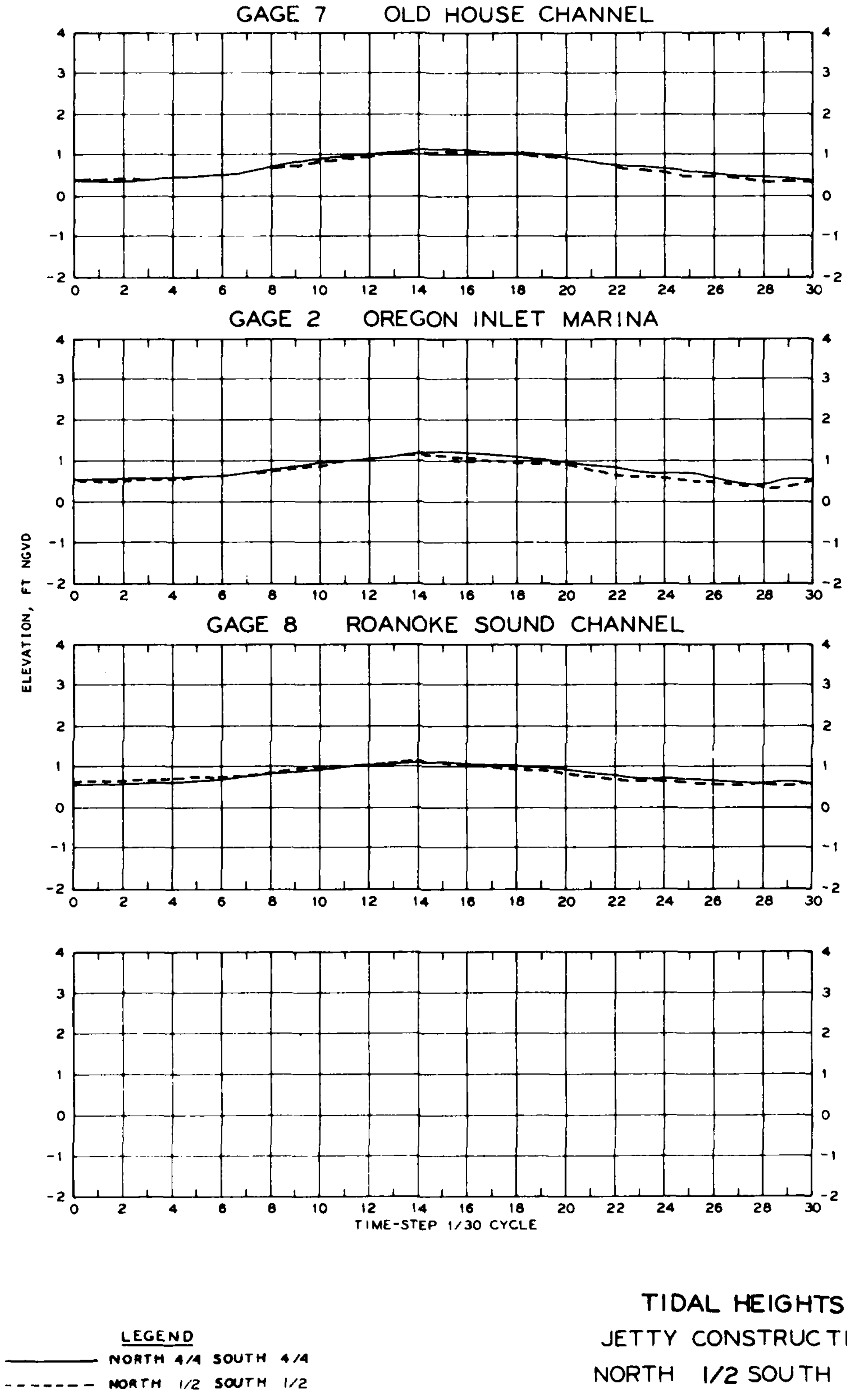


LEGEND

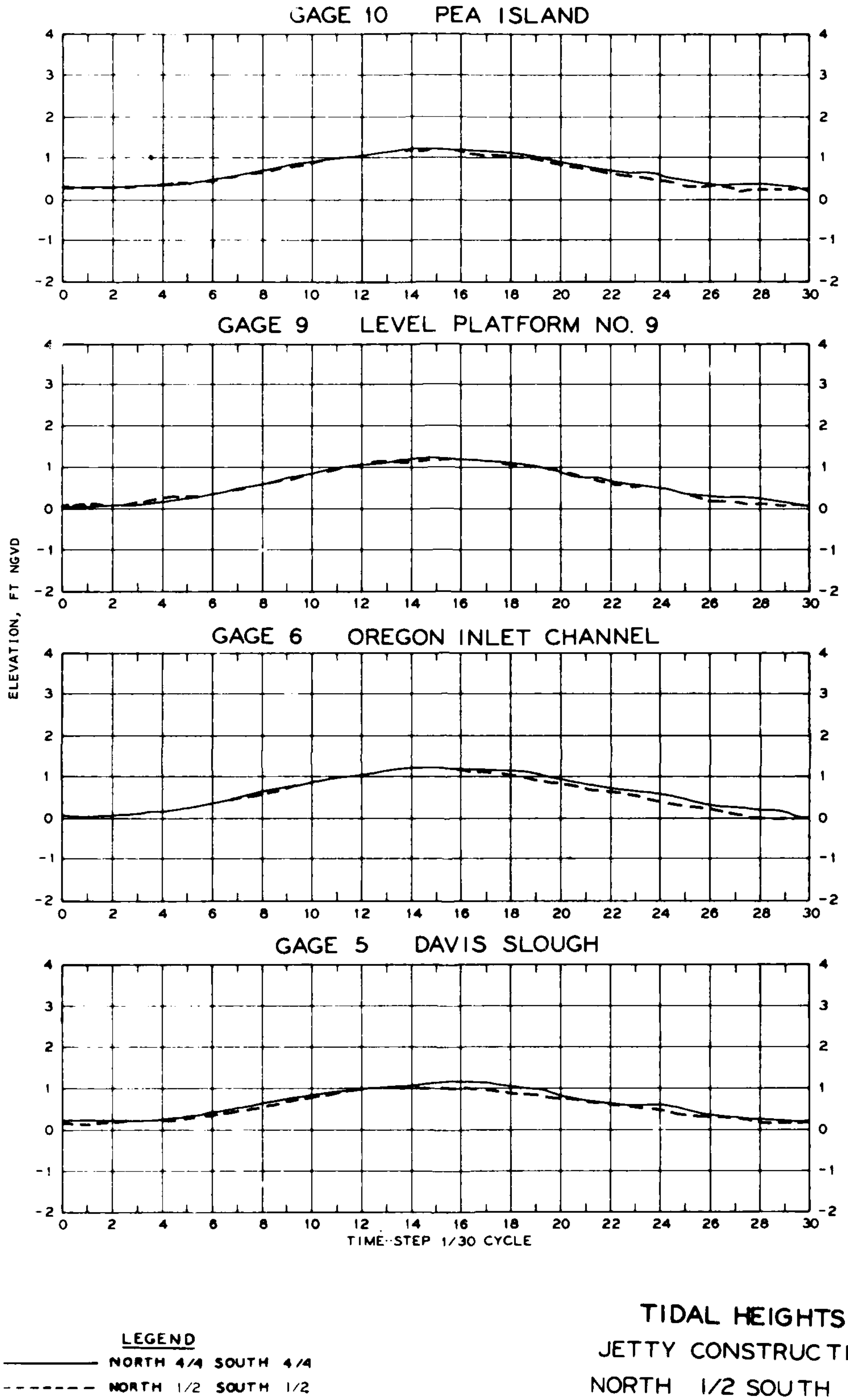
——— NORTH 4/4 SOUTH 4/4

- - - - - NORTH 1/2 SOUTH 1/2

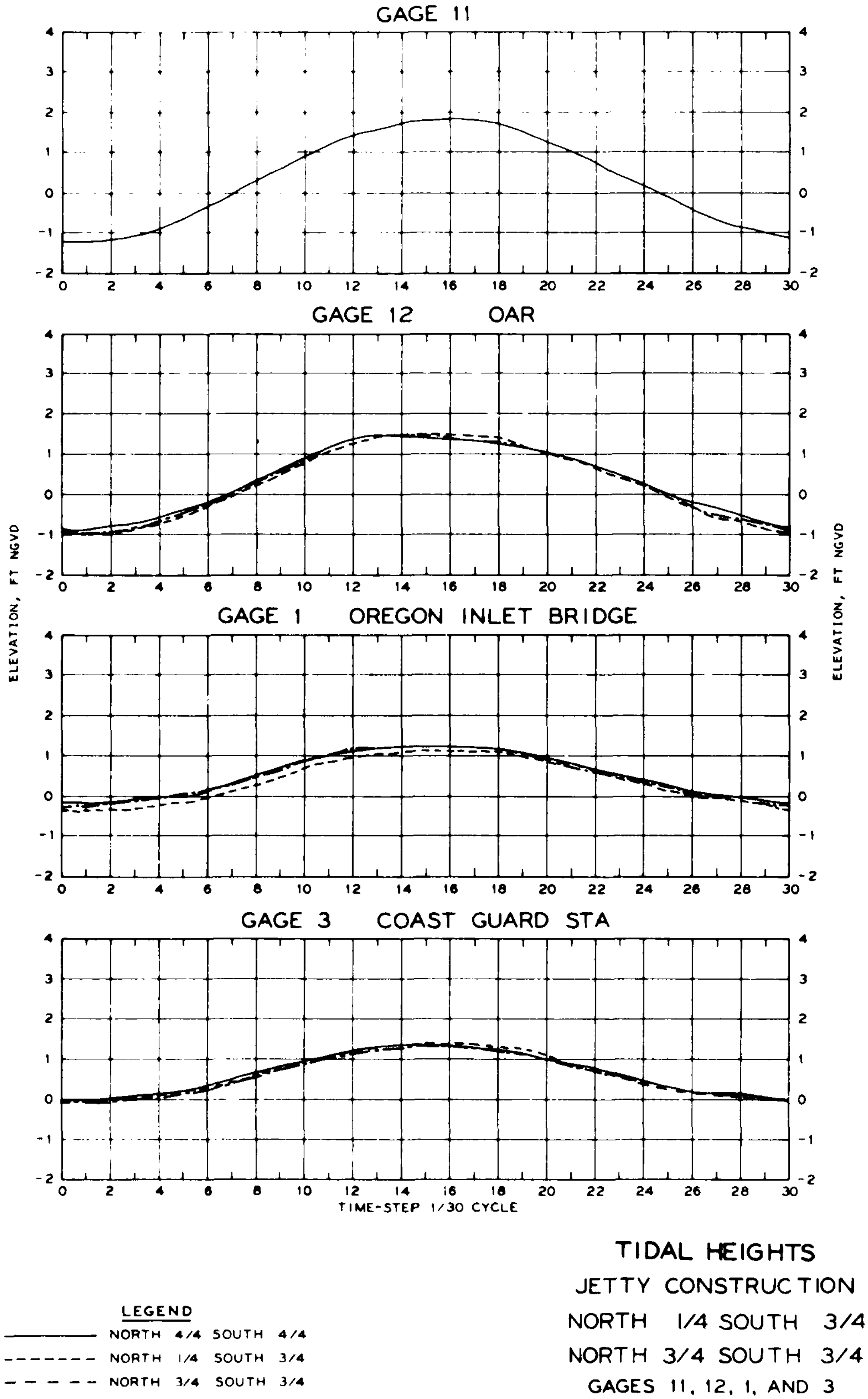
TIDAL HEIGHTS
JETTY CONSTRUCTION
NORTH 1/2 SOUTH 1/2
GAGES 11, 12, 1, AND 3



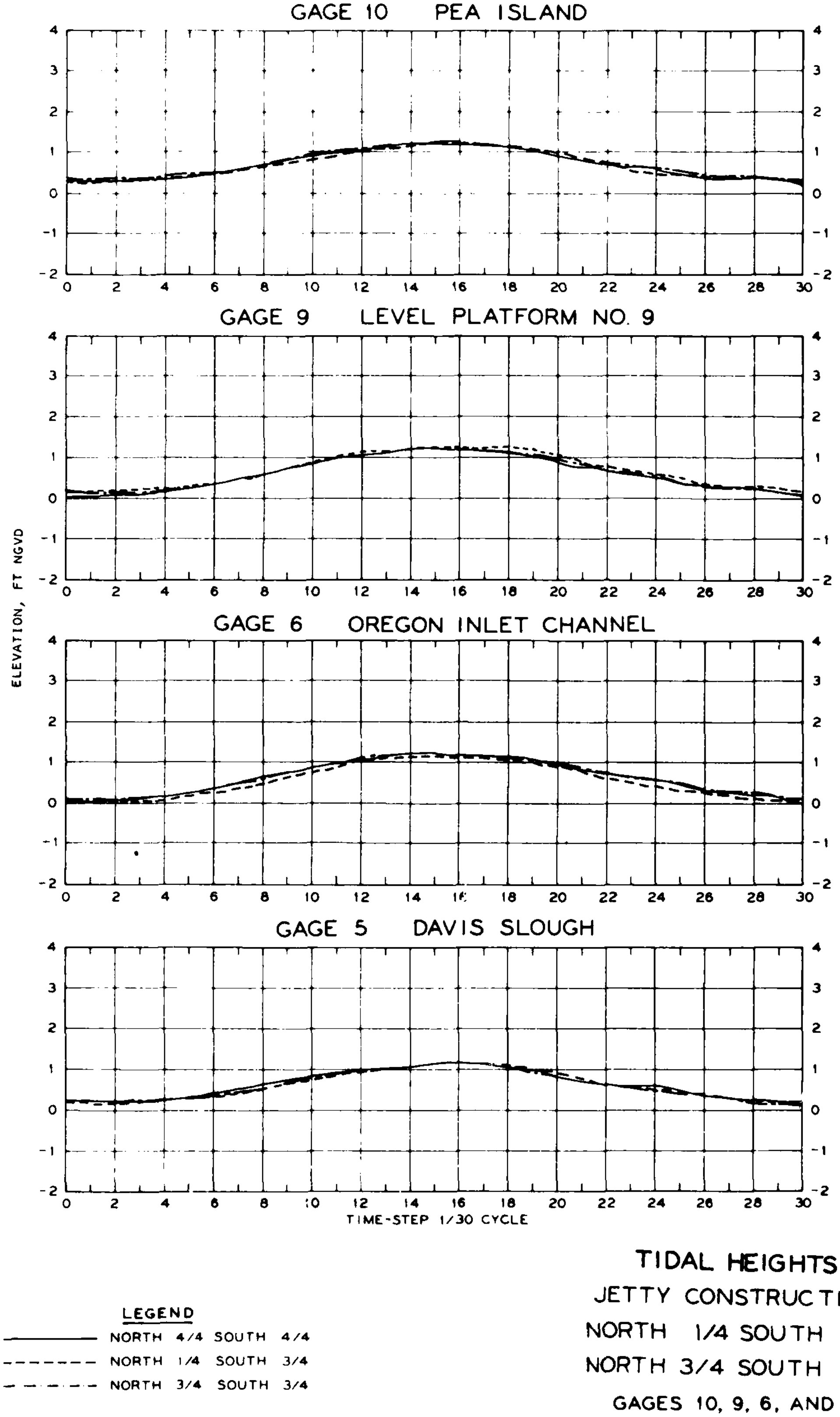
TIDAL HEIGHTS
JETTY CONSTRUCTION
NORTH 1/2 SOUTH 1/2
GAGES 7, 2, AND 8



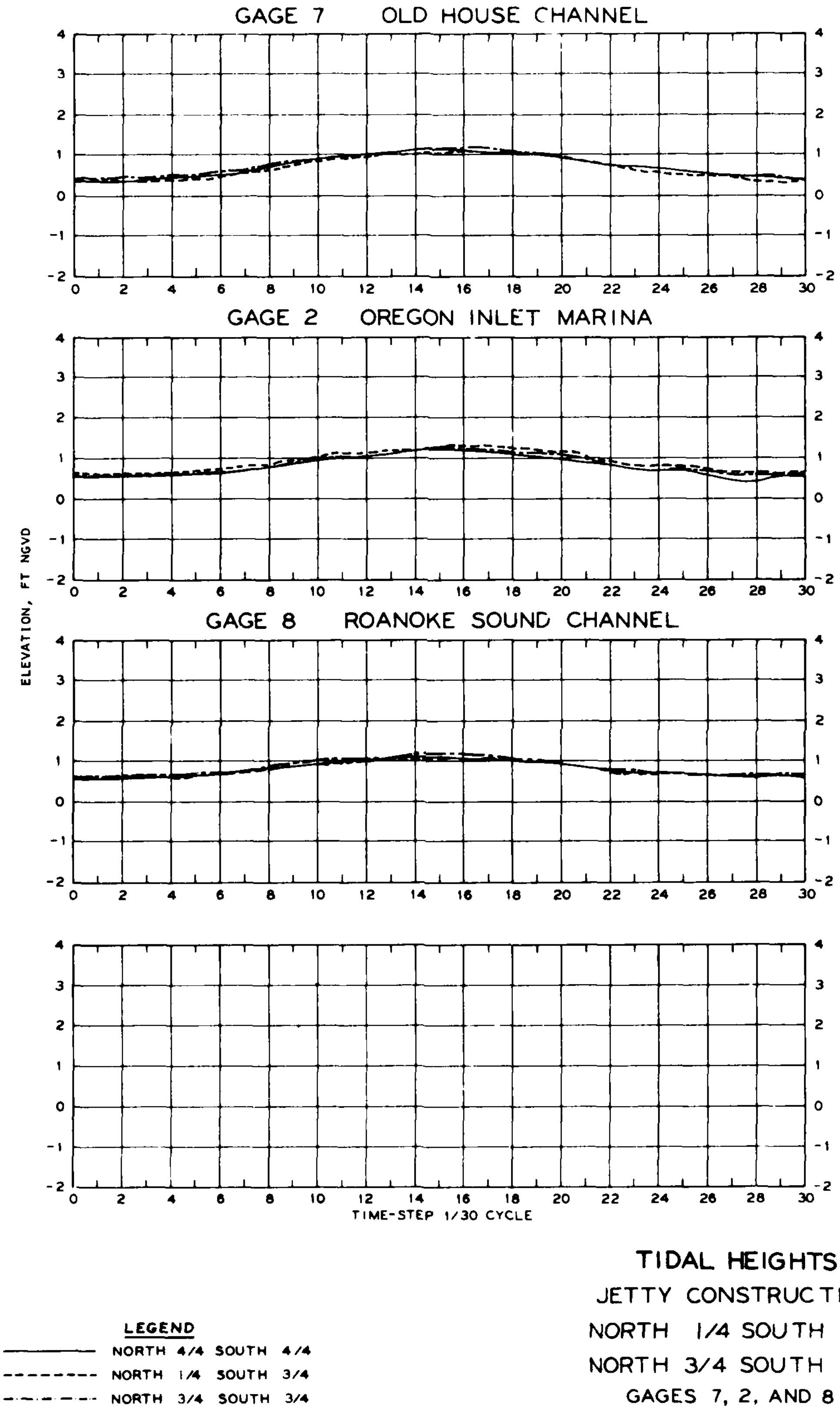
TIDAL HEIGHTS
JETTY CONSTRUCTION
NORTH 1/2 SOUTH 1/2
GAGES 10, 9, 6, AND 5



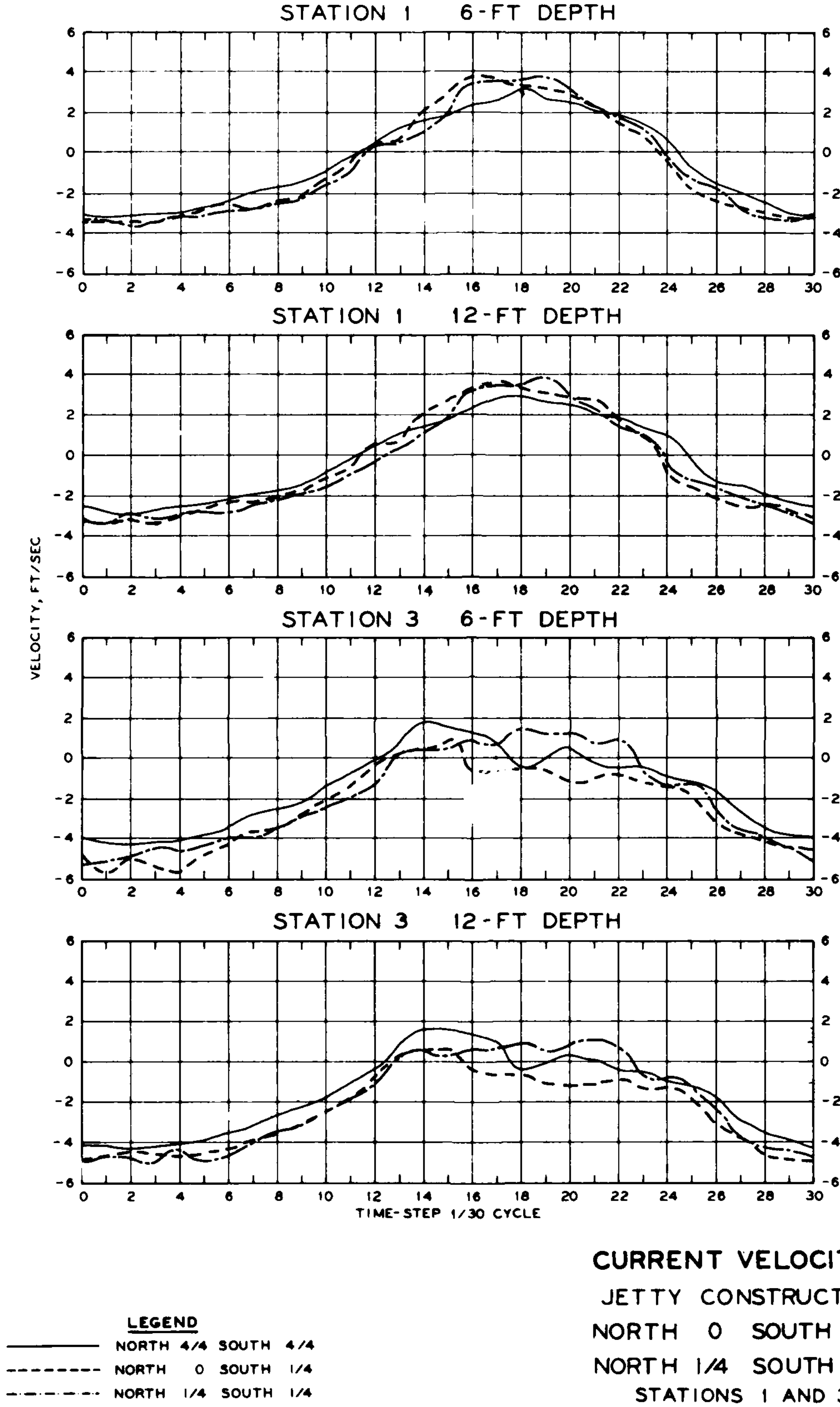
TIDAL HEIGHTS
JETTY CONSTRUCTION
NORTH 1/4 SOUTH 3/4
NORTH 3/4 SOUTH 3/4
GAGES 11, 12, 1, AND 3



TIDAL HEIGHTS
JETTY CONSTRUCTION
NORTH 1/4 SOUTH 3/4
NORTH 3/4 SOUTH 3/4
GAGES 10, 9, 6, AND 5



TIDAL HEIGHTS
JETTY CONSTRUCTION
NORTH 1/4 SOUTH 3/4
NORTH 3/4 SOUTH 3/4
GAGES 7, 2, AND 8



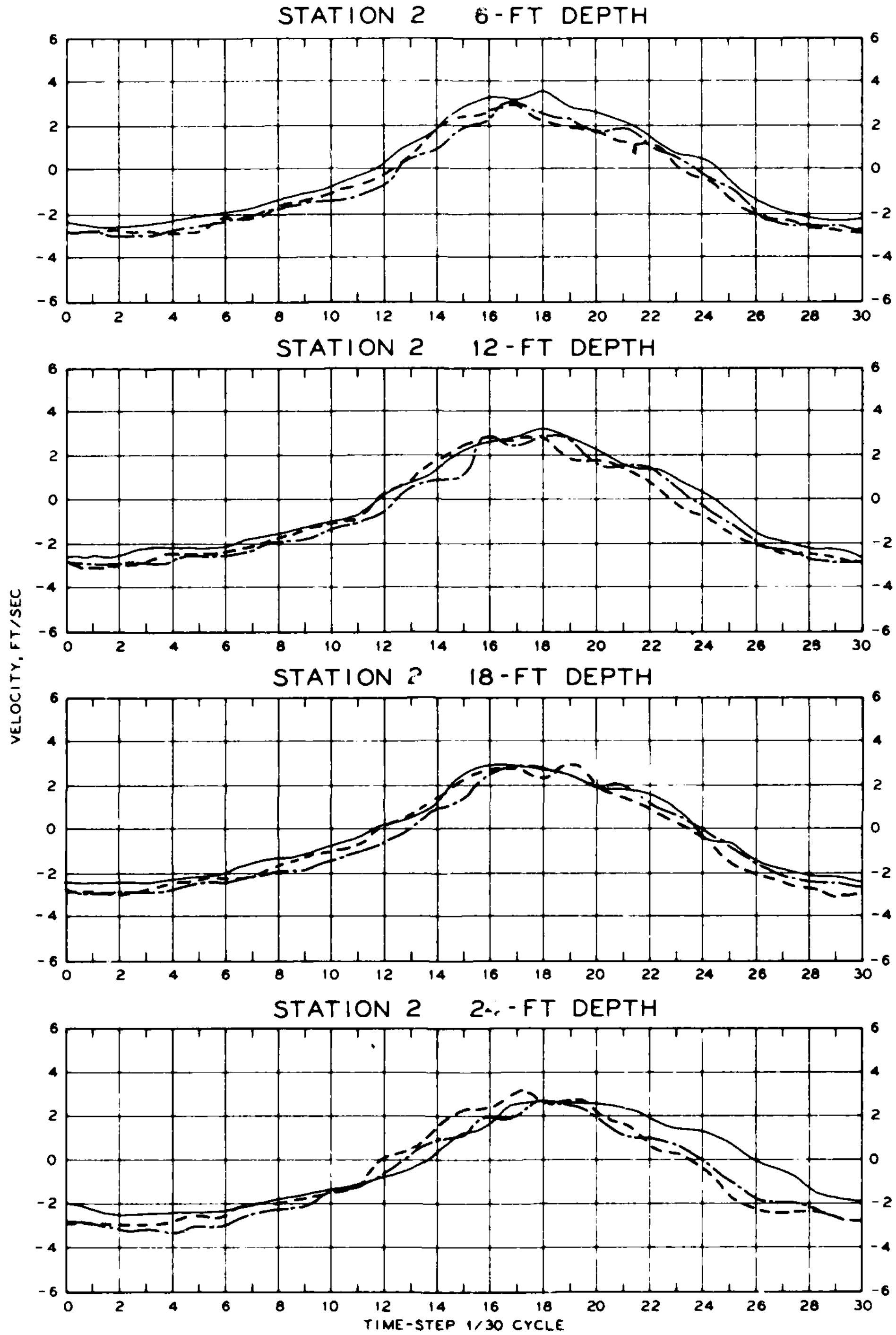
CURRENT VELOCITIES

JETTY CONSTRUCTION

NORTH 0 SOUTH 1/4

NORTH 1/4 SOUTH 1/4

STATIONS 1 AND 3



LEGEND

- NORTH 4/4 SOUTH 4/4
- NORTH 0 SOUTH 1/4
- NORTH 1/4 SOUTH 1/4

CURRENT VELOCITIES

JETTY CONSTRUCTION

NORTH 0 SOUTH 1/4

NORTH 1/4 SOUTH 1/4

STATION 2

AD-A131 999 HYDRAULIC MODEL INVESTIGATION: FUNCTIONAL DESIGN OF CONTROL STRUCTURES FO..(U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS HYDRA..

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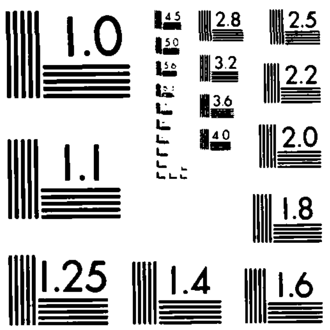
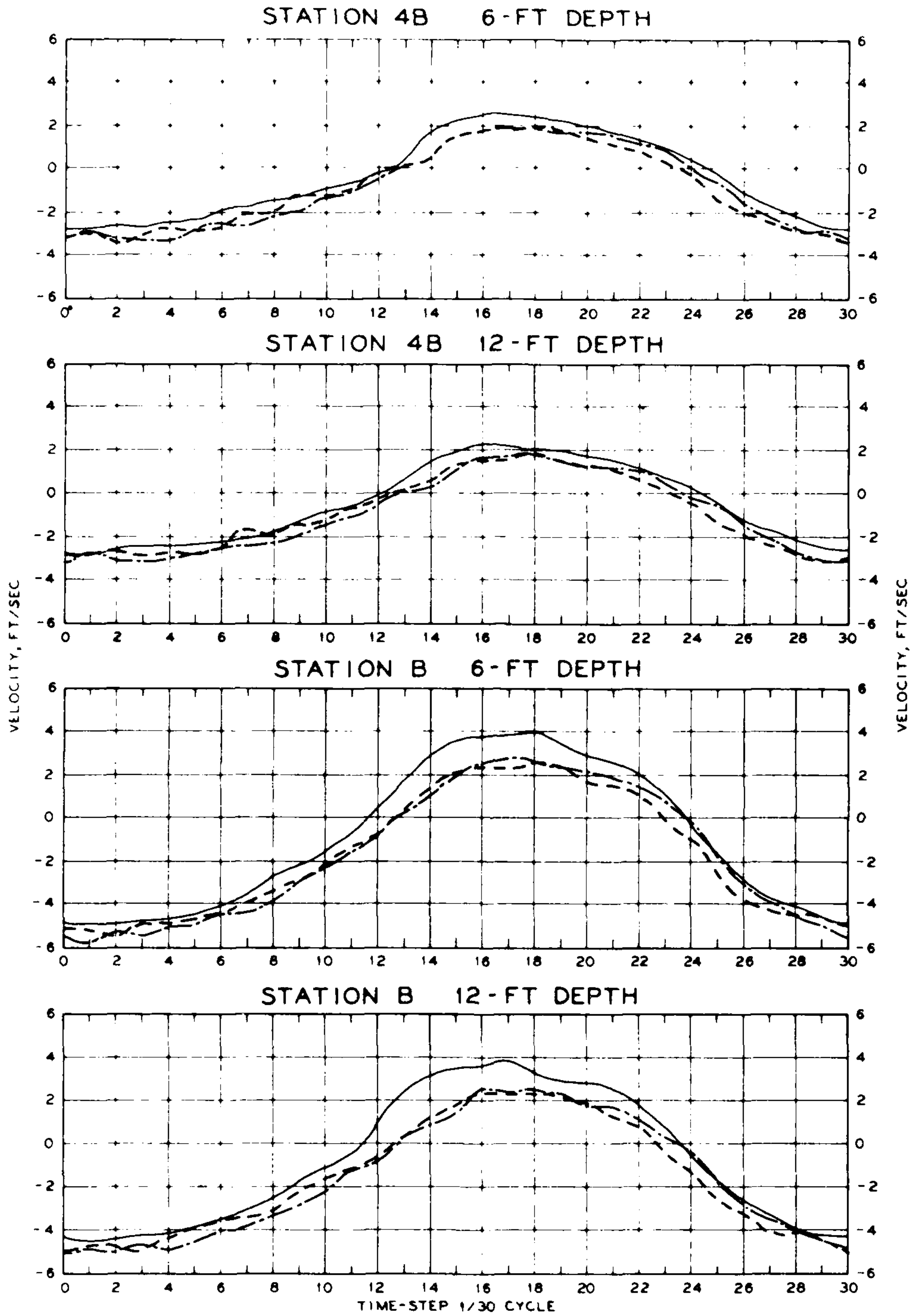
cont.



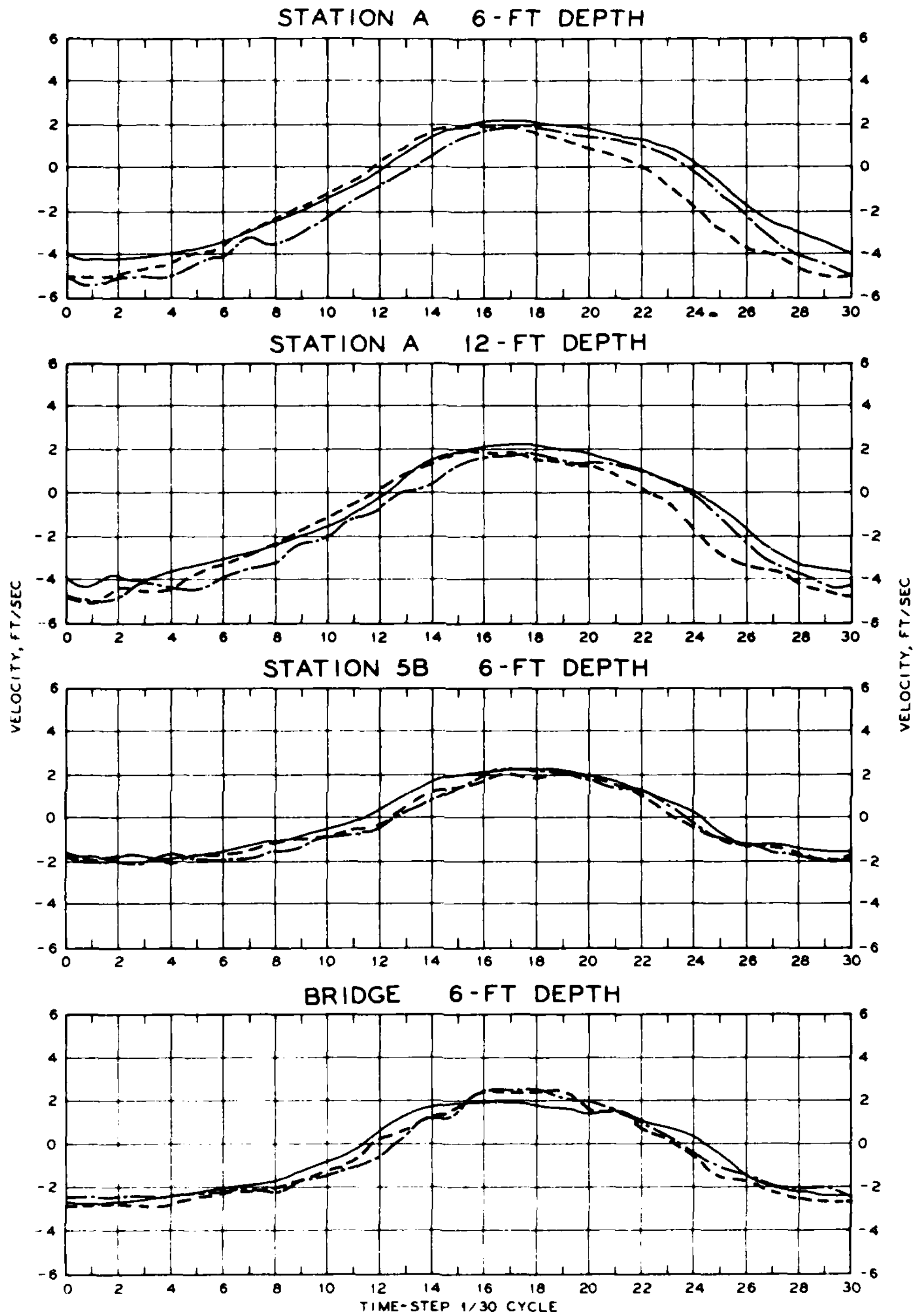
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



LEGEND

- ——— NORTH 4/4 SOUTH 4/4
- - - - - NORTH 0 SOUTH 1/4
- — — — NORTH 1/4 SOUTH 1/4

CURRENT VELOCITIES
JETTY CONSTRUCTION
NORTH 0 SOUTH 1/4
NORTH 1/4 SOUTH 1/4
STATIONS 4B AND B



LEGEND

————	NORTH 4/4 SOUTH 4/4
- - - - - - -	NORTH 0 SOUTH 1/4
— - — - —	NORTH 1/4 SOUTH 1/4

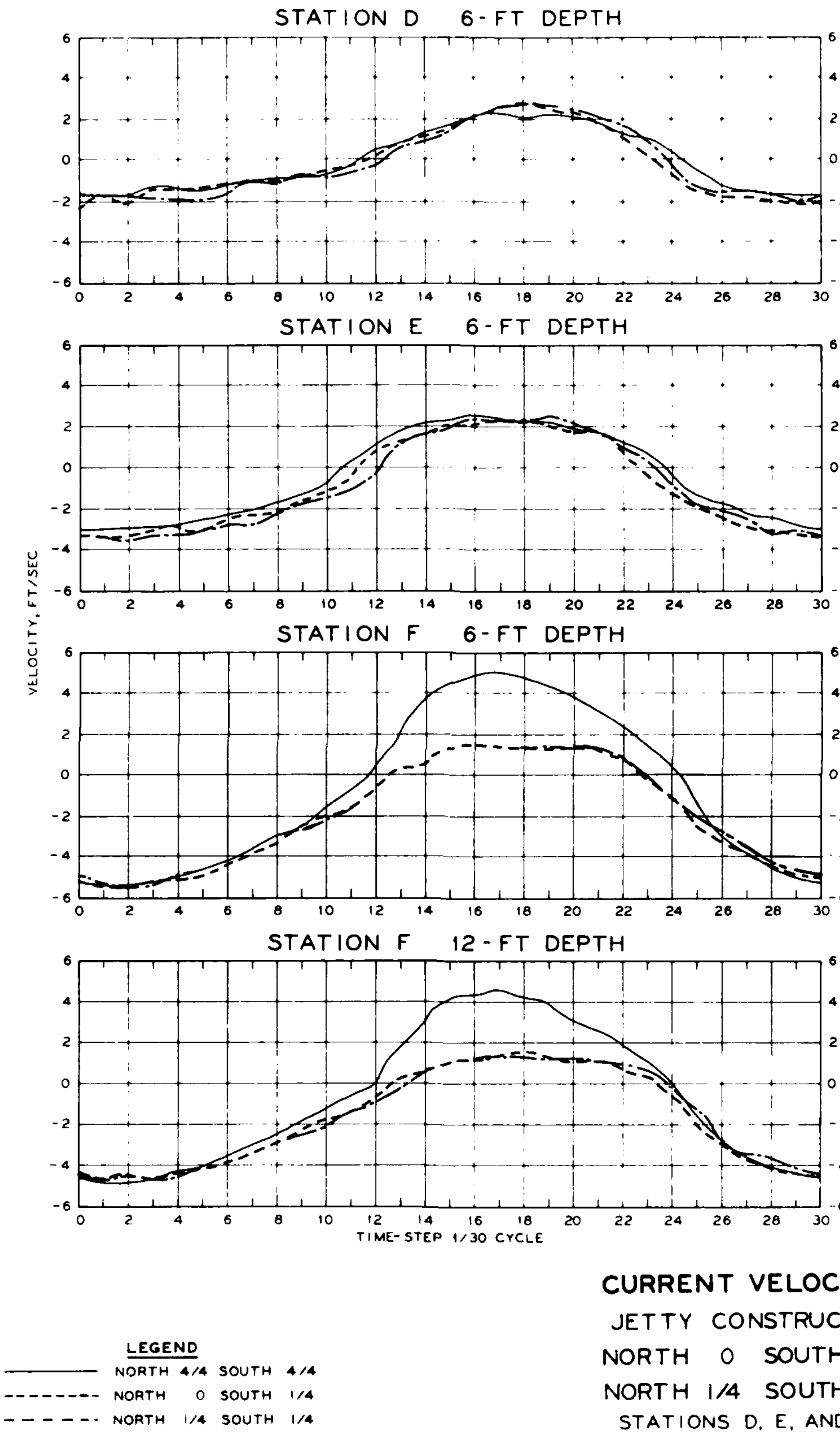
CURRENT VELOCITIES

JETTY CONSTRUCTION

NORTH 0 SOUTH 1/4

NORTH 1/4 SOUTH 1/4

STATIONS A, 5B, AND BRIDGE



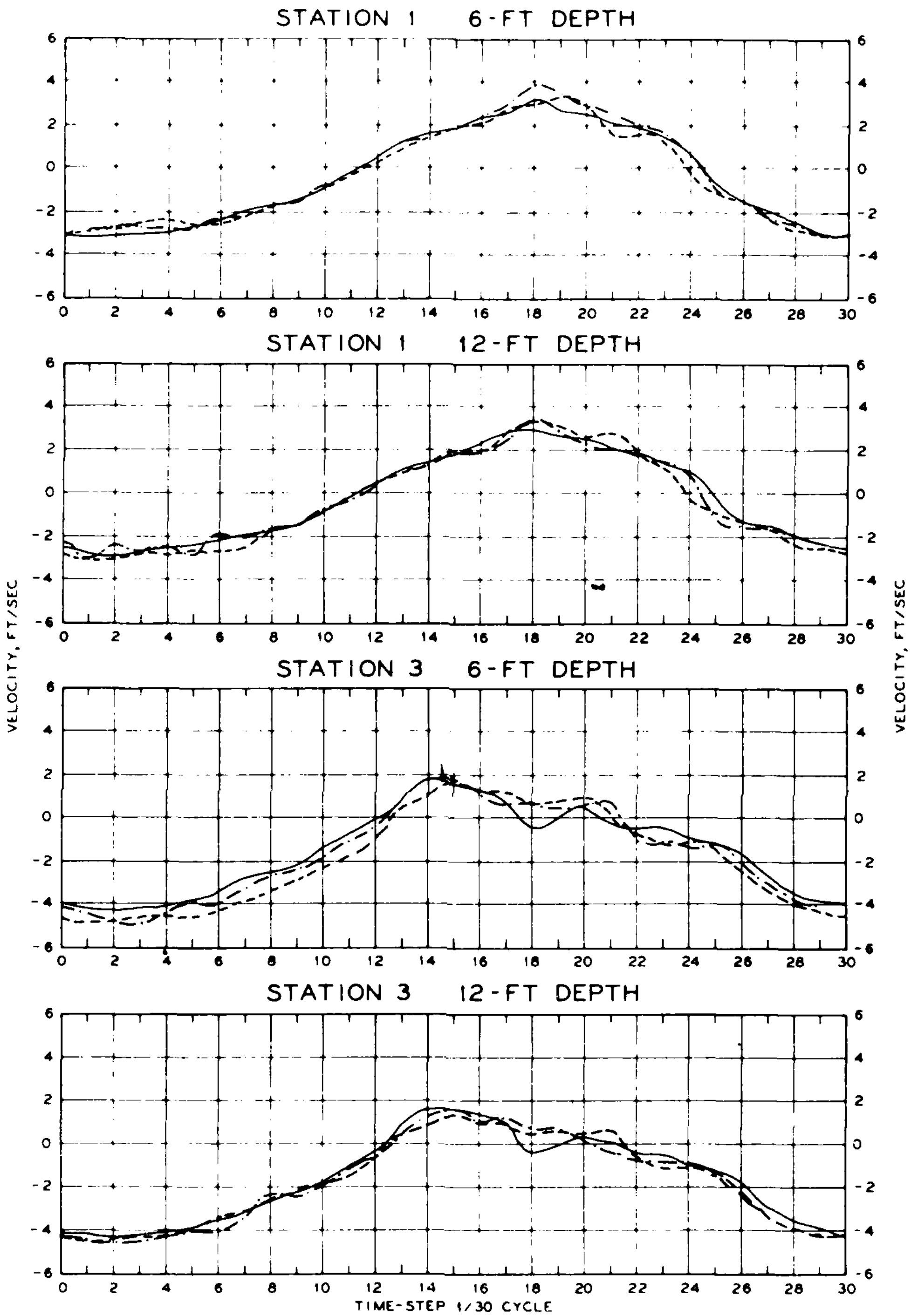
CURRENT VELOCITIES

JETTY CONSTRUCTION

NORTH 0 SOUTH 1/4

NORTH 1/4 SOUTH 1/4

STATIONS D, E, AND F



LEGEND

——— NORTH 4/4 SOUTH 4/4

------ NORTH 3/4 SOUTH 4/4

-·-·-·- NORTH 1/2 SOUTH 4/4

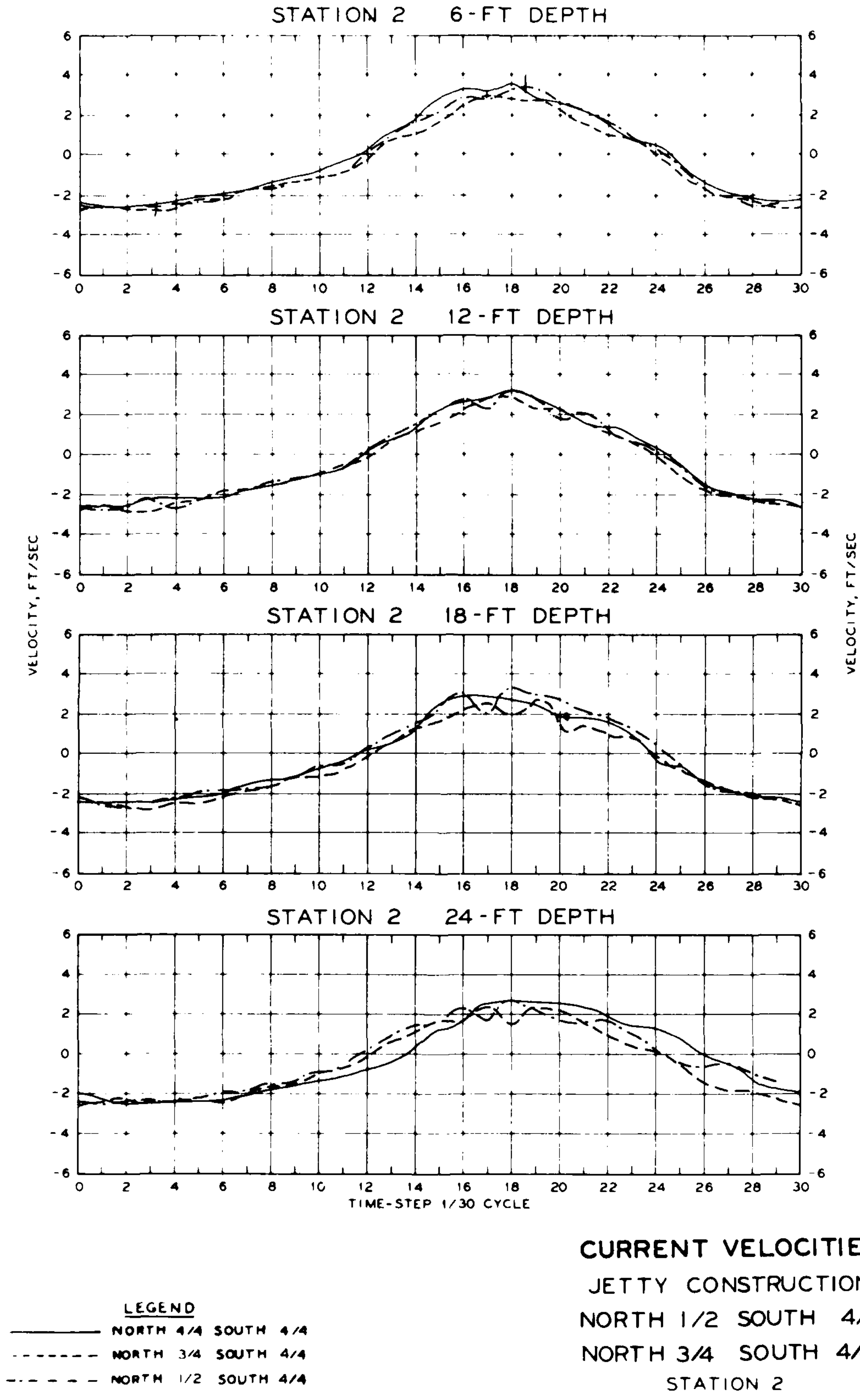
CURRENT VELOCITIES

JETTY CONSTRUCTION

NORTH 1/2 SOUTH 4/4

NORTH 3/4 SOUTH 4/4

STATIONS 1 AND 3



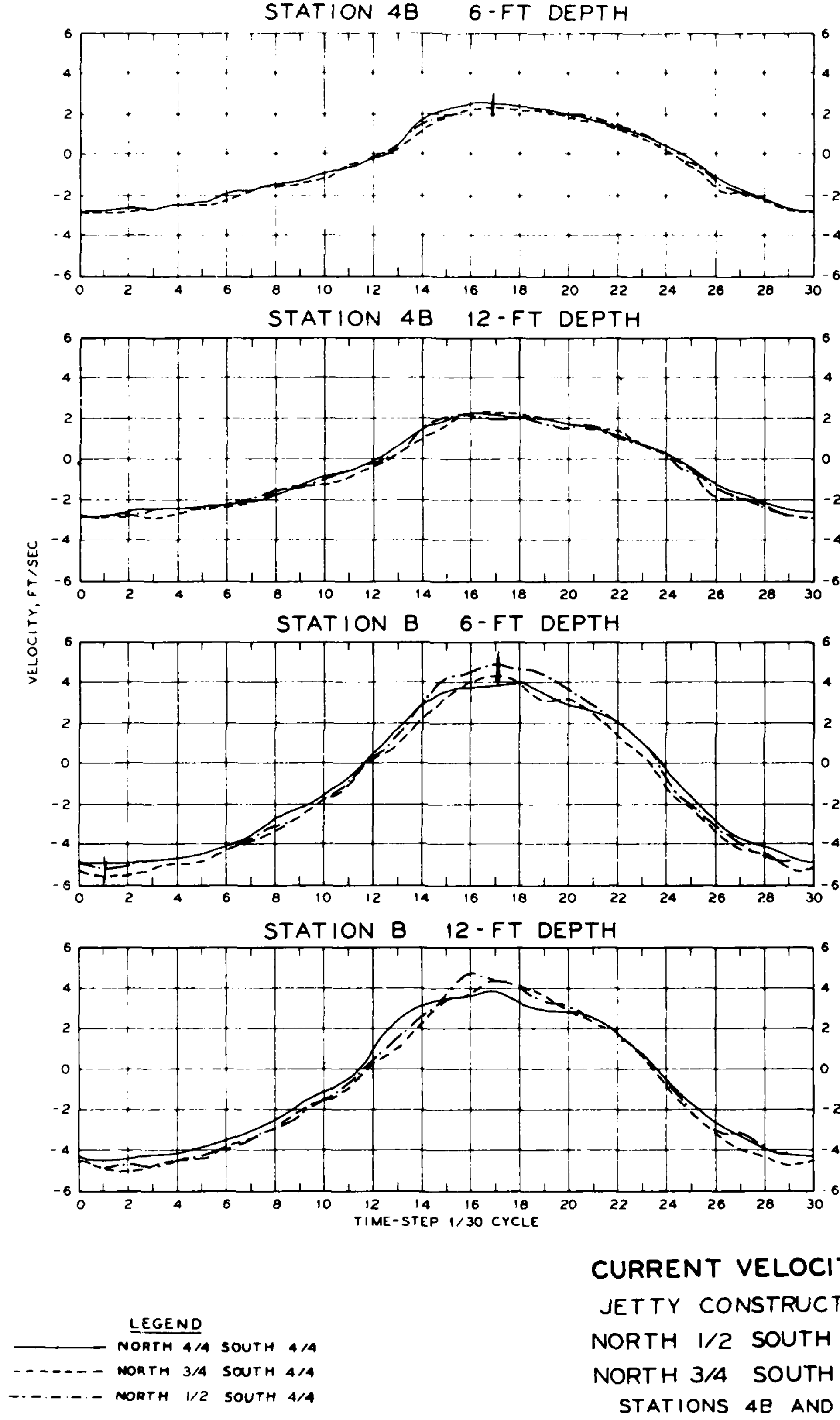
CURRENT VELOCITIES

JETTY CONSTRUCTION

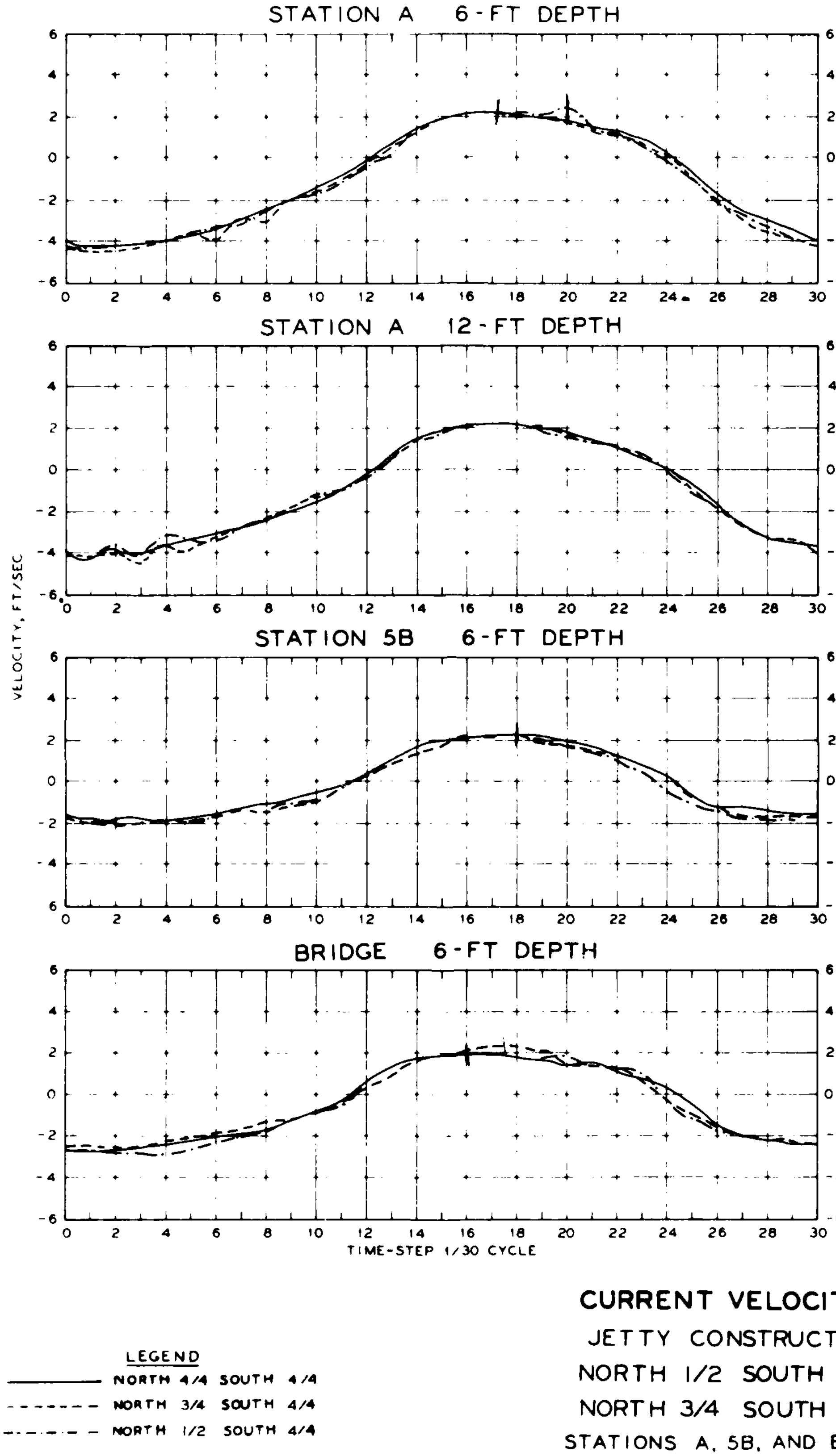
NORTH 1/2 SOUTH 4/4

NORTH 3/4 SOUTH 4/4

STATION 2



CURRENT VELOCITIES
JETTY CONSTRUCTION
NORTH 1/2 SOUTH 4/4
NORTH 3/4 SOUTH 4/4
STATIONS 4B AND B



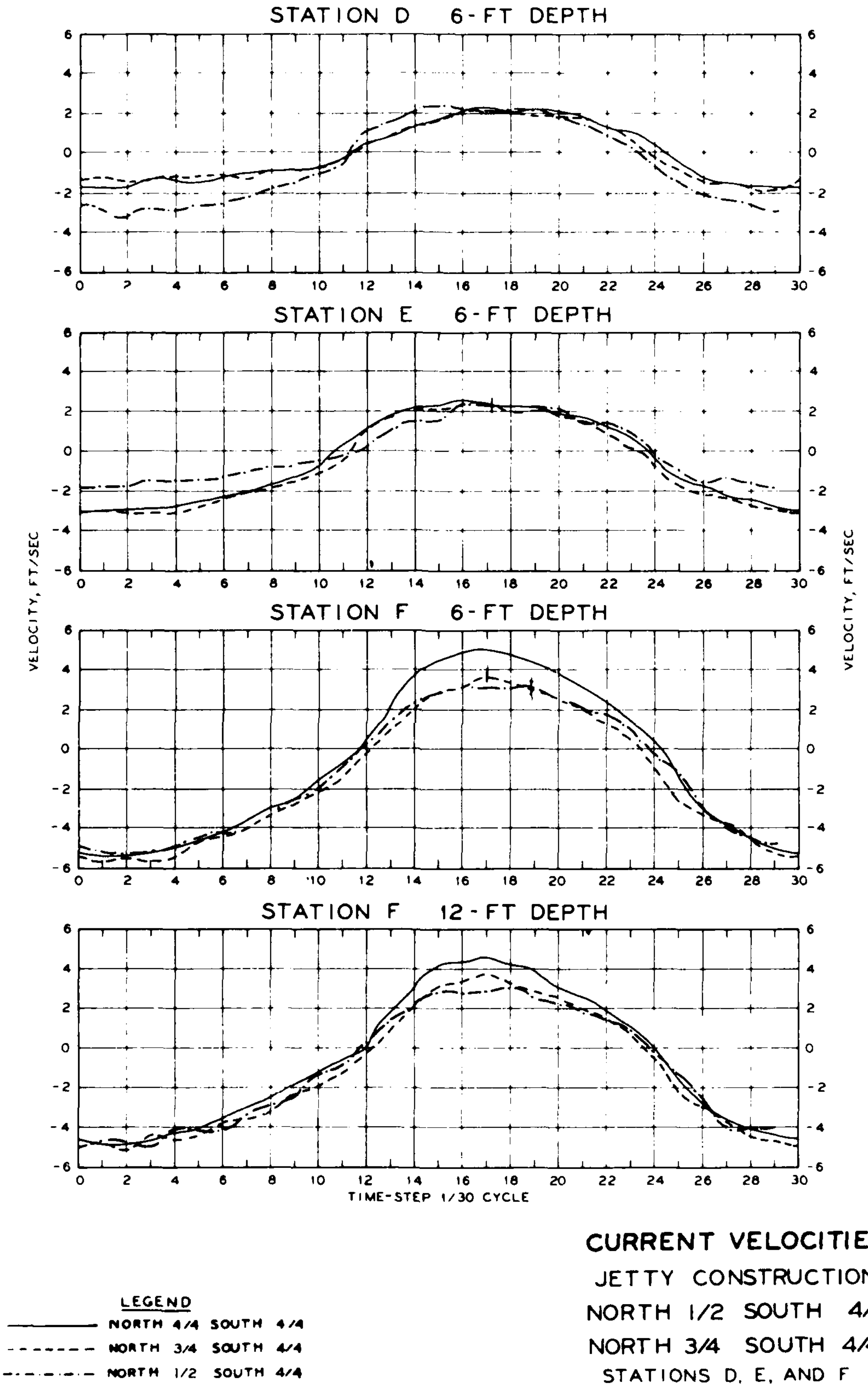
CURRENT VELOCITIES

JETTY CONSTRUCTION

NORTH 1/2 SOUTH 4/4

NORTH 3/4 SOUTH 4/4

STATIONS A, 5B, AND BRIDGE



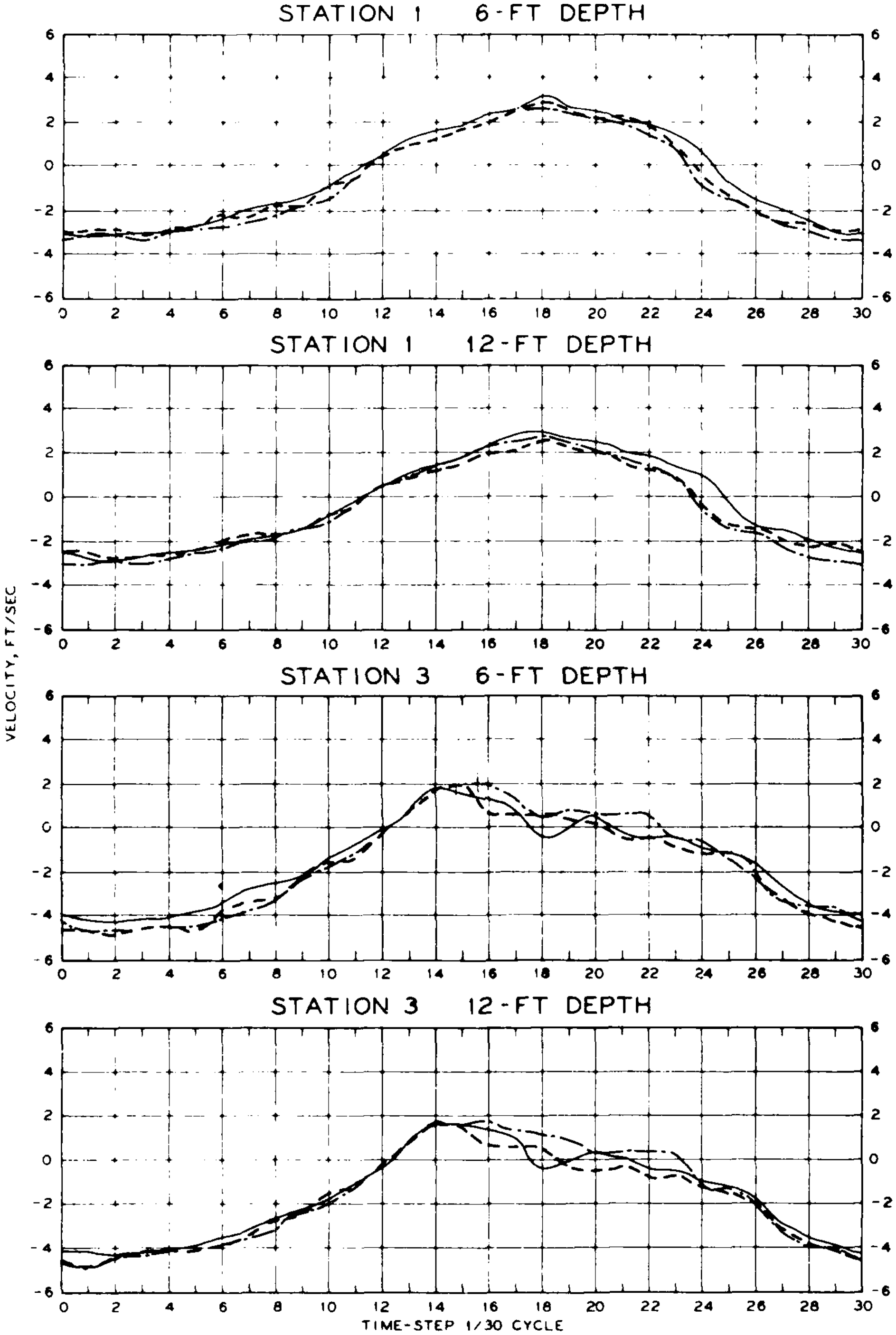
CURRENT VELOCITIES

JETTY CONSTRUCTION

NORTH 1/2 SOUTH 4/4

NORTH 3/4 SOUTH 4/4

STATIONS D, E, AND F



LEGEND

- NORTH 1/4 SOUTH 4/4
- NORTH 0 SOUTH 1/2
- NORTH 0 SOUTH 3/4

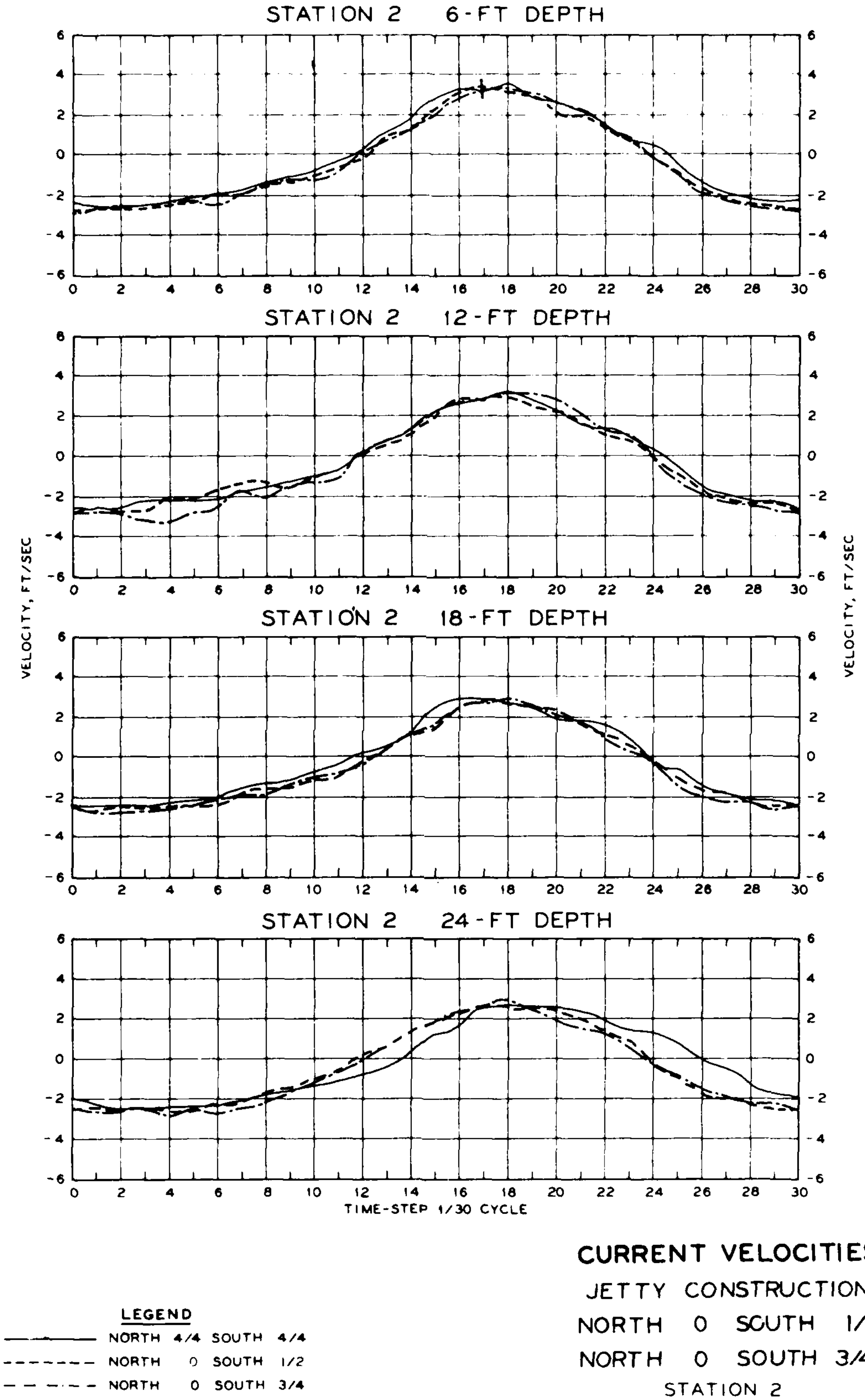
CURRENT VELOCITIES

JETTY CONSTRUCTION

NORTH 0 SOUTH 1/2

NORTH 0 SOUTH 3/4

STATIONS 1 AND 3



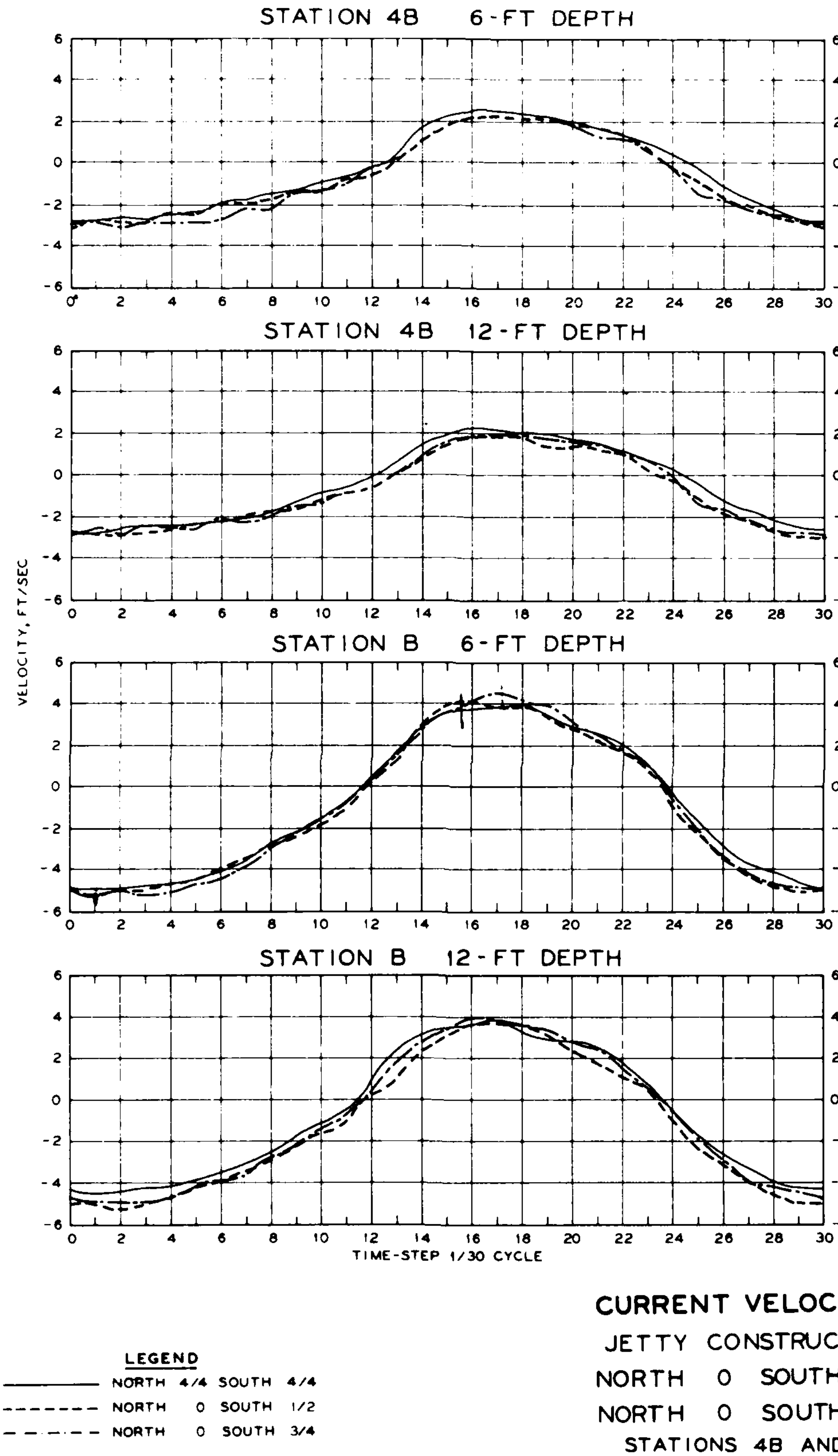
CURRENT VELOCITIES

JETTY CONSTRUCTION

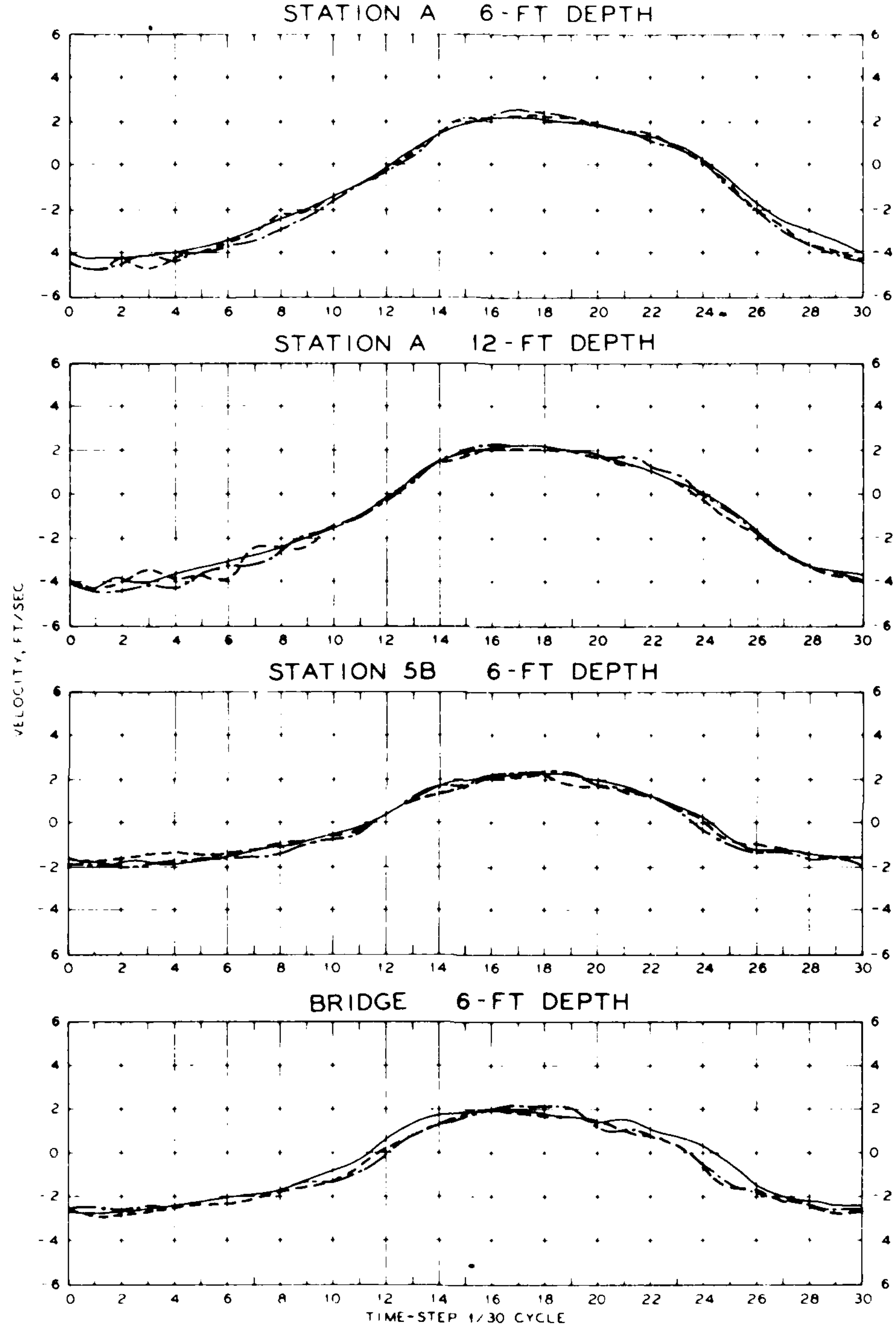
NORTH 0 SOUTH 1/2

NORTH 0 SOUTH 3/4

STATION 2



CURRENT VELOCITIES
JETTY CONSTRUCTION
NORTH 0 SOUTH 1/2
NORTH 0 SOUTH 3/4
STATIONS 4B AND B



CURRENT VELOCITIES

JETTY CONSTRUCTION

NORTH 0 SOUTH 1/2

NORTH 0 SOUTH 3/4

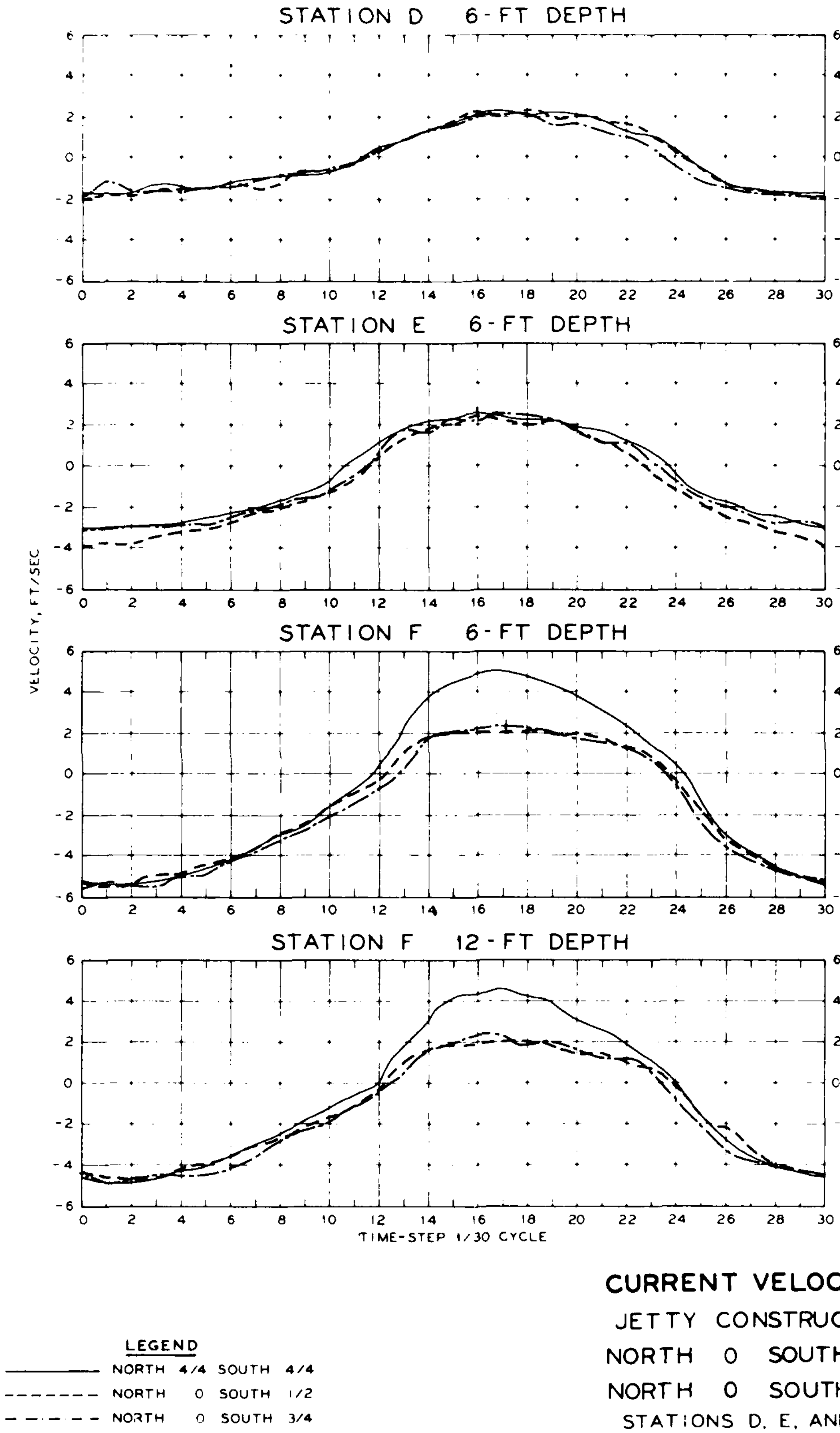
STATIONS A, 5B, AND BRIDGE

LEGEND

NORTH 4/4 SOUTH 4/4

NORTH 0 SOUTH 1/2

NORTH 0 SOUTH 3/4



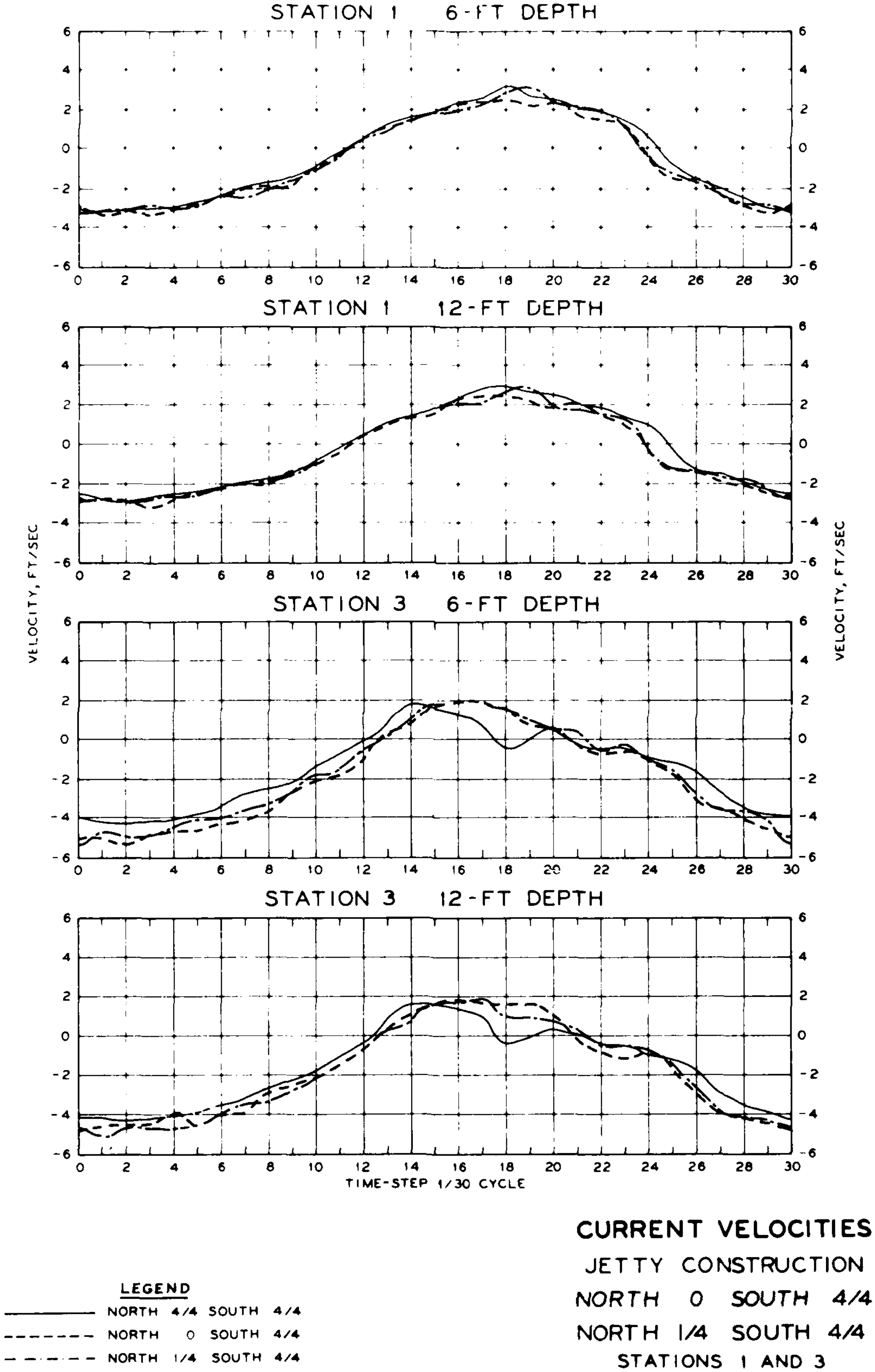
CURRENT VELOCITIES

JETTY CONSTRUCTION

NORTH 0 SOUTH 1/2

NORTH 0 SOUTH 3/4

STATIONS D, E, AND F



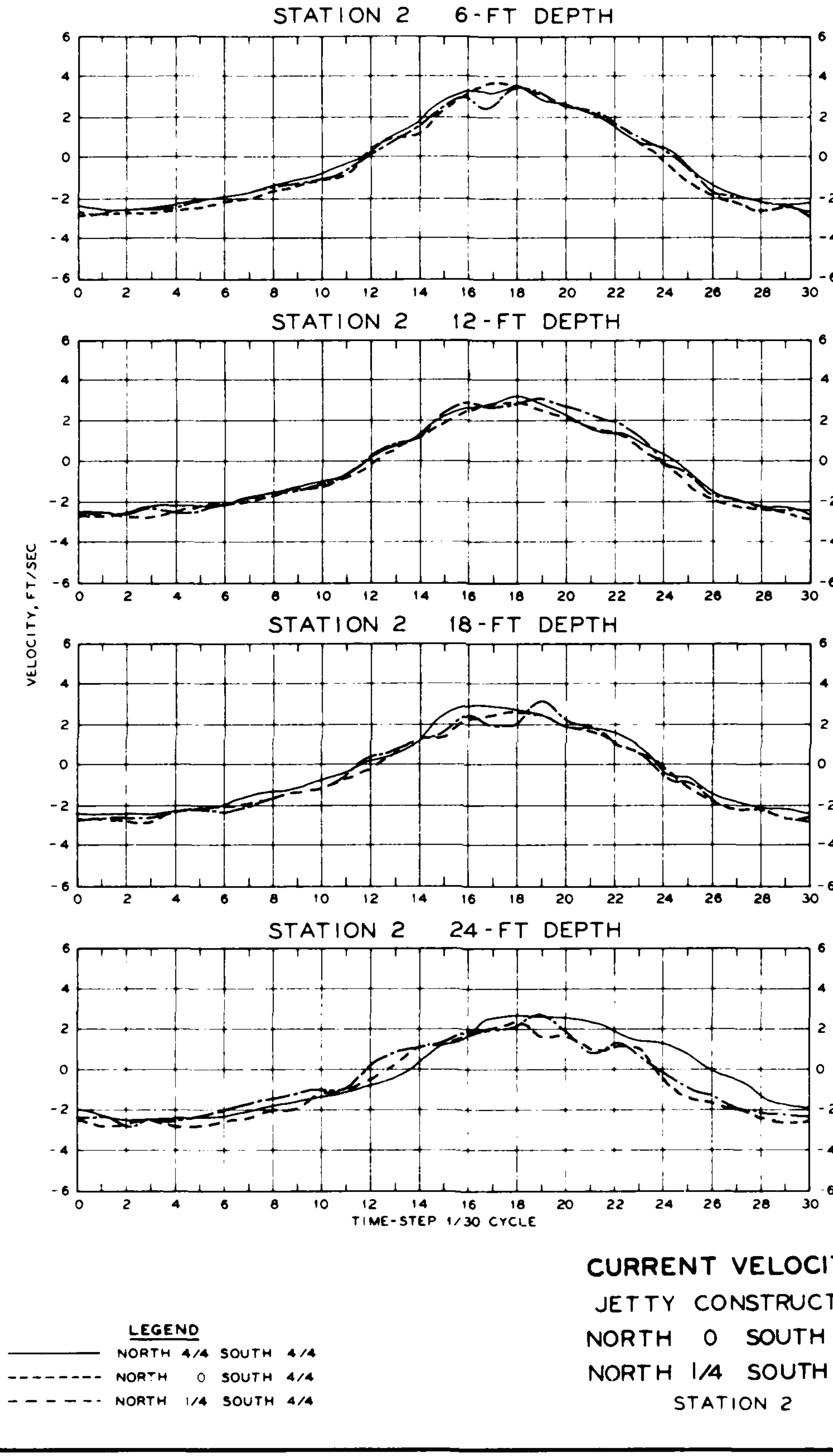
CURRENT VELOCITIES

JETTY CONSTRUCTION

NORTH 0 SOUTH 4/4

NORTH 1/4 SOUTH 4/4

STATIONS 1 AND 3



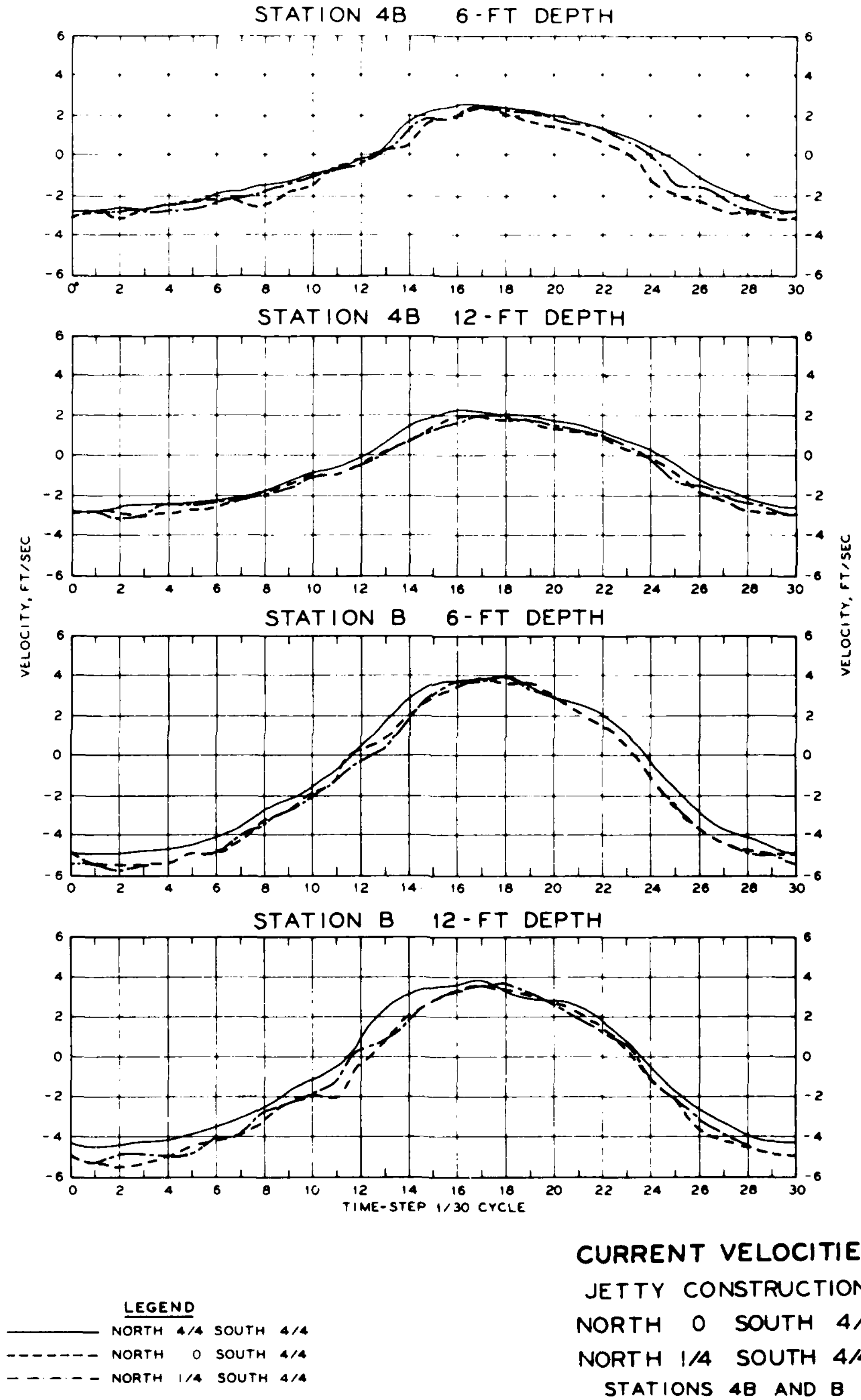
CURRENT VELOCITIES

JETTY CONSTRUCTION

NORTH 0 SOUTH 4/4

NORTH 1/4 SOUTH 4/4

STATION 2



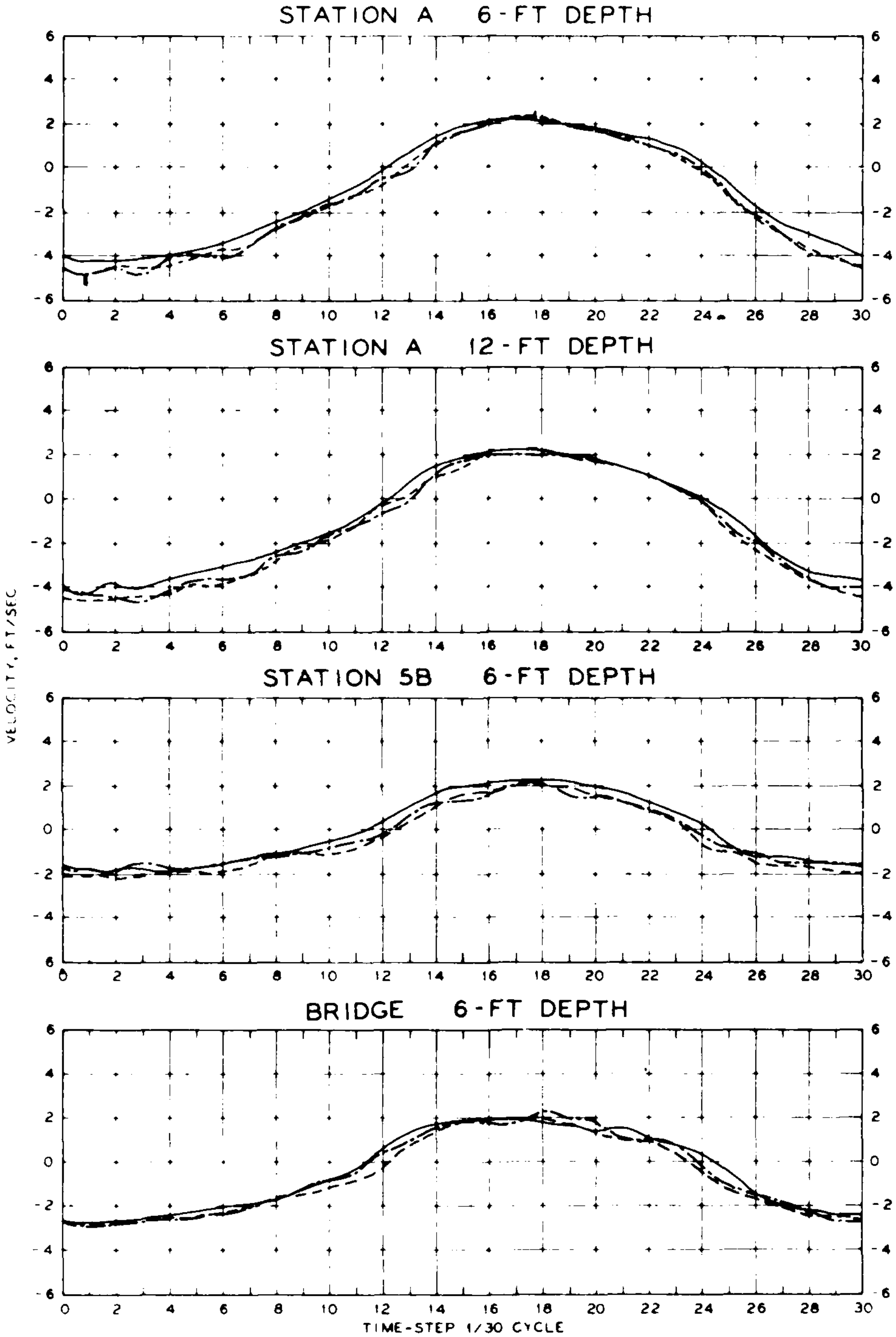
CURRENT VELOCITIES

JETTY CONSTRUCTION

NORTH 0 SOUTH 4/4

NORTH 1/4 SOUTH 4/4

STATIONS 4B AND B



LEGEND

- ——— NORTH 4/4 SOUTH 4/4
- - - - - NORTH 0 SOUTH 4/4
- — — — NORTH 1/4 SOUTH 4/4

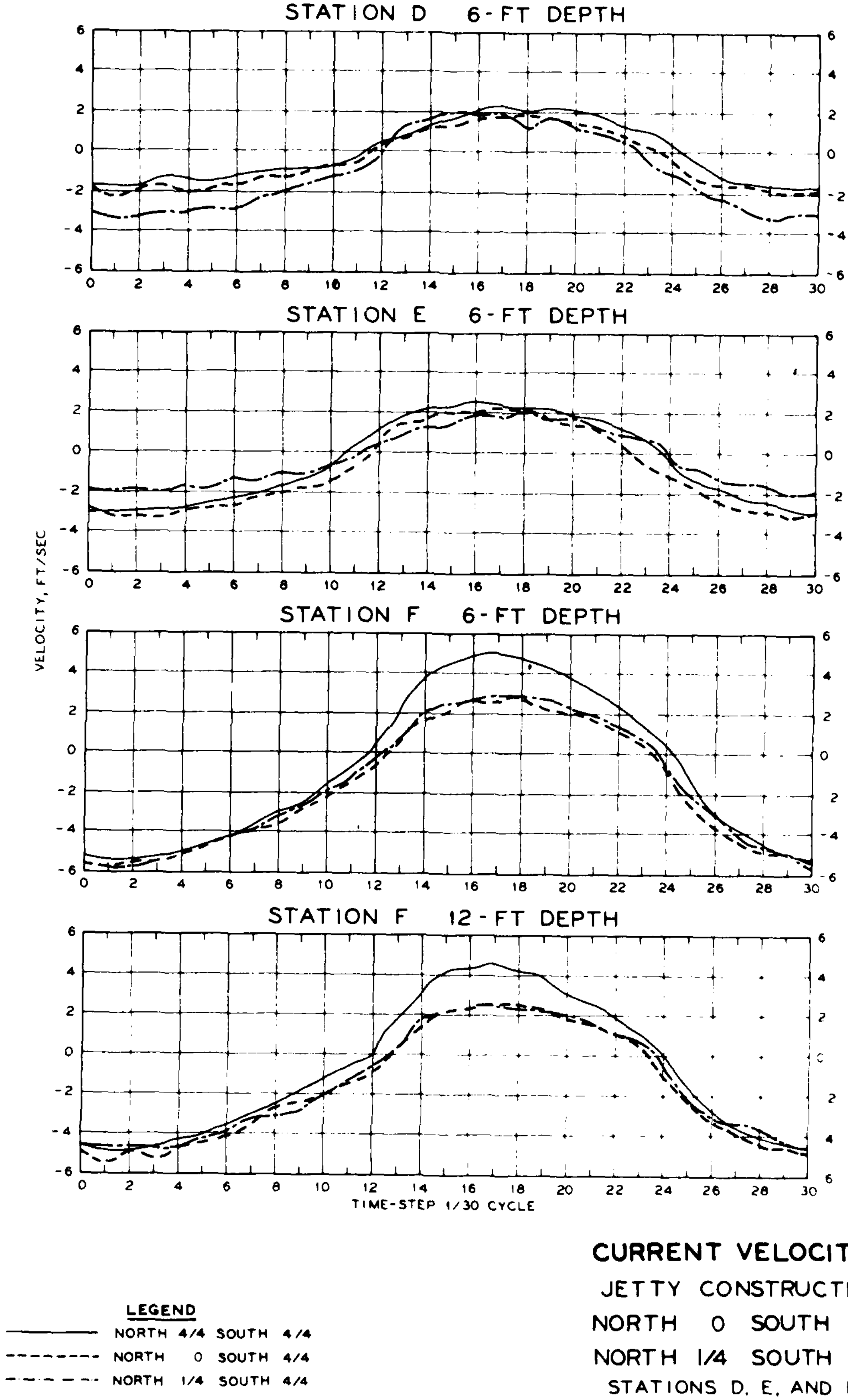
CURRENT VELOCITIES

JETTY CONSTRUCTION

NORTH 0 SOUTH 4/4

NORTH 1/4 SOUTH 4/4

STATIONS A, 5B, AND BRIDGE



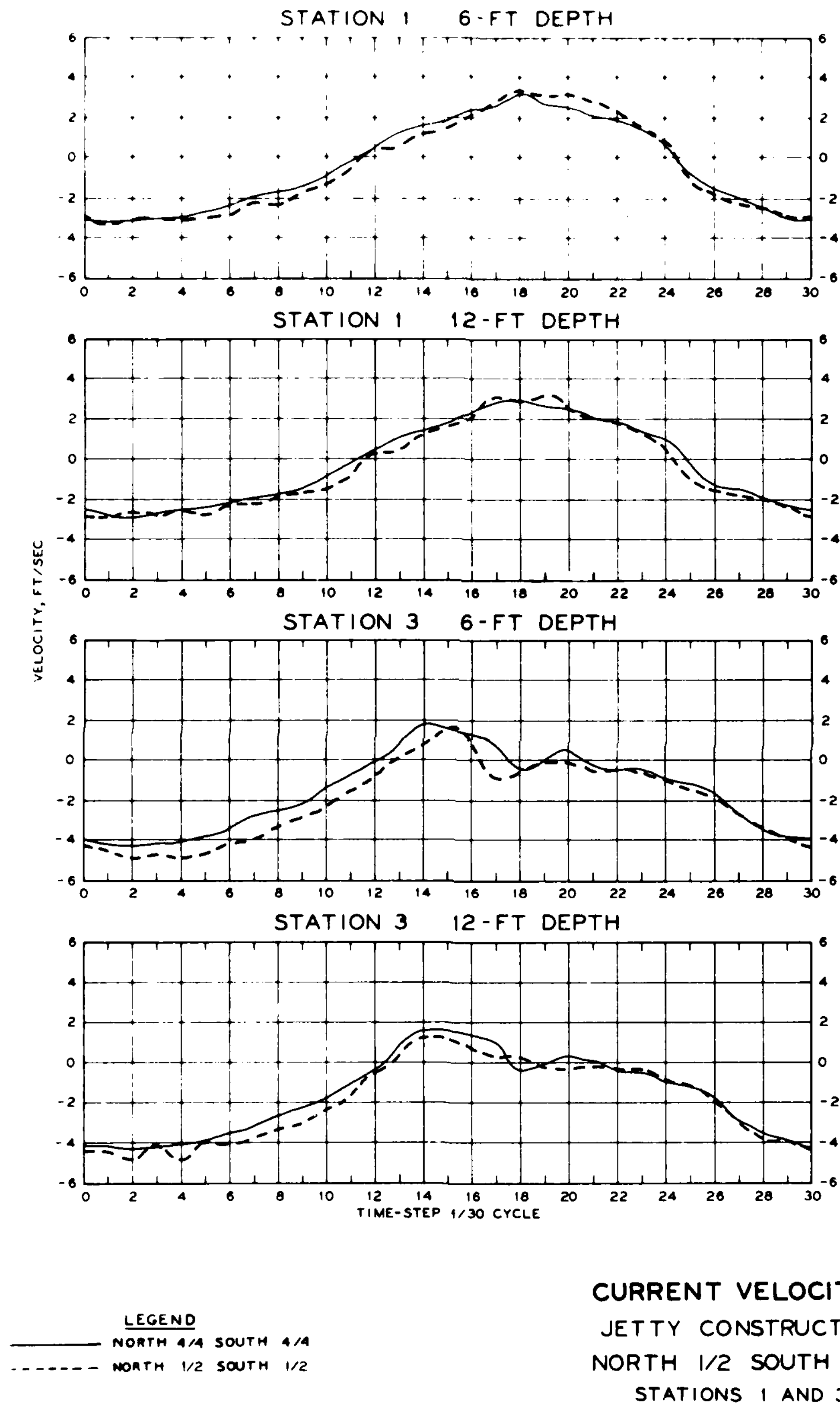
CURRENT VELOCITIES

JETTY CONSTRUCTION

NORTH 0 SOUTH 4/4

NORTH 1/4 SOUTH 4/4

STATIONS D, E, AND F

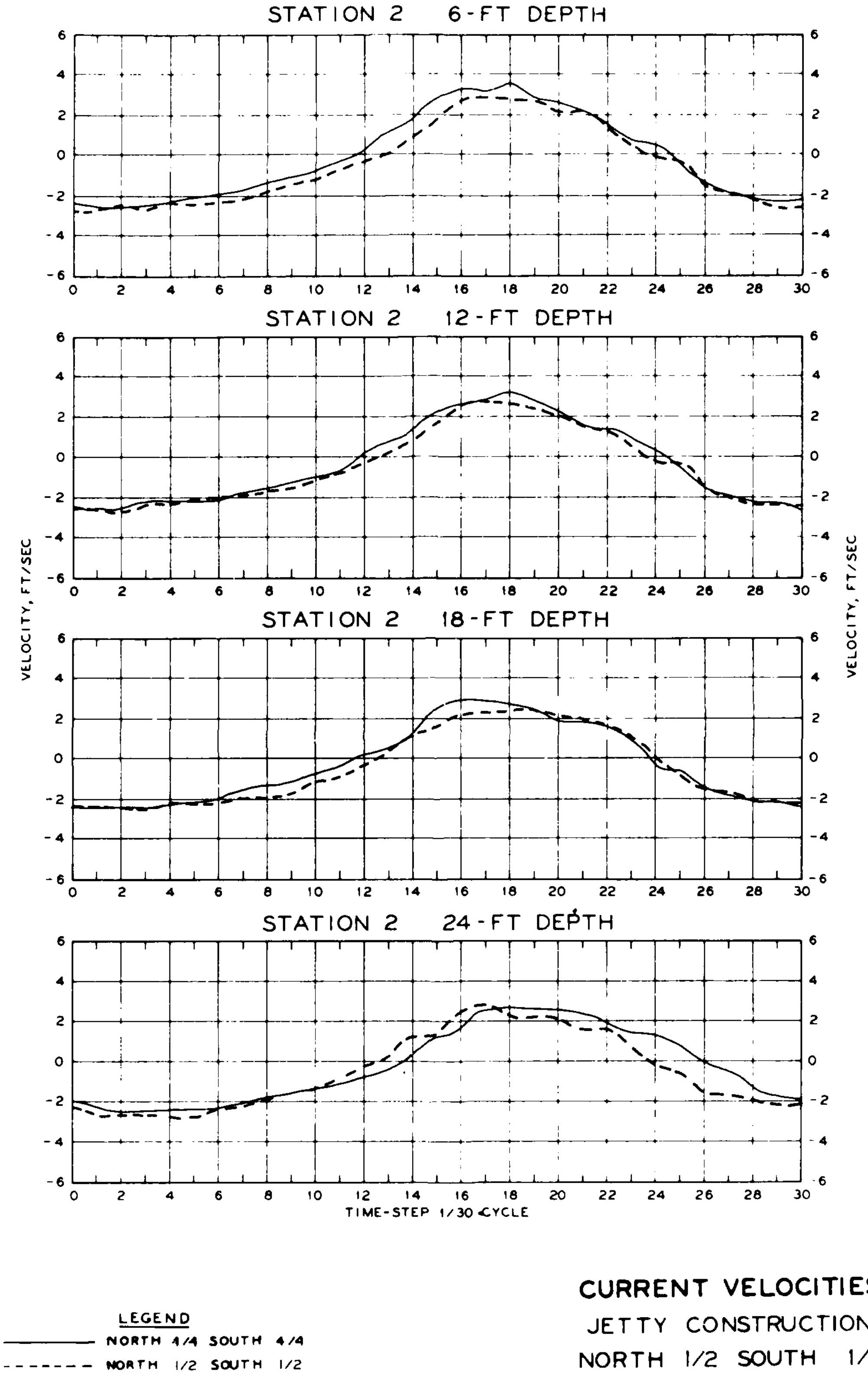


CURRENT VELOCITIES

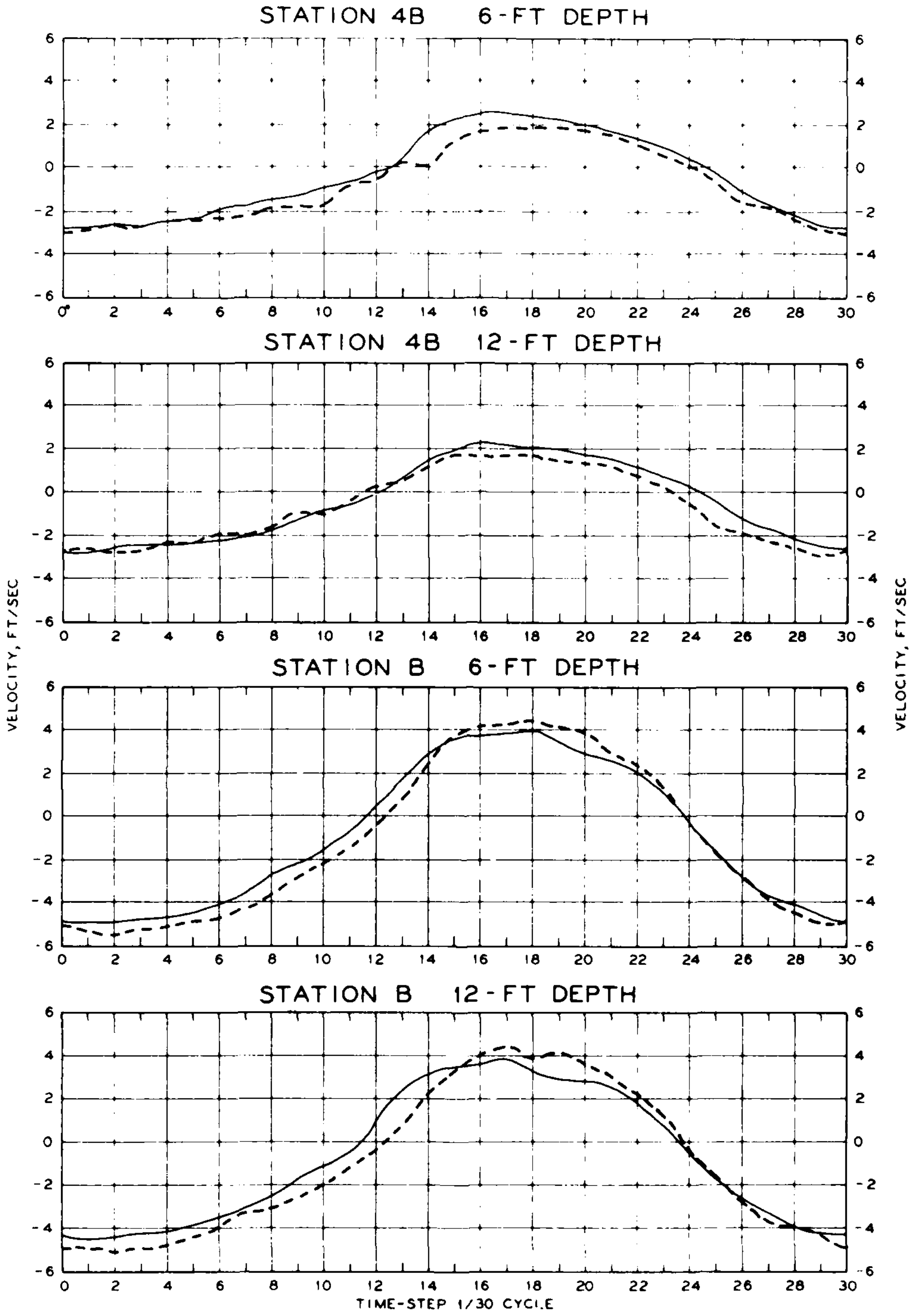
JETTY CONSTRUCTION

NORTH 1/2 SOUTH 1/2

STATIONS 1 AND 3



CURRENT VELOCITIES
JETTY CONSTRUCTION
NORTH 1/2 SOUTH 1/2
STATION 2



LEGEND

——— NORTH 4/4 SOUTH 4/4

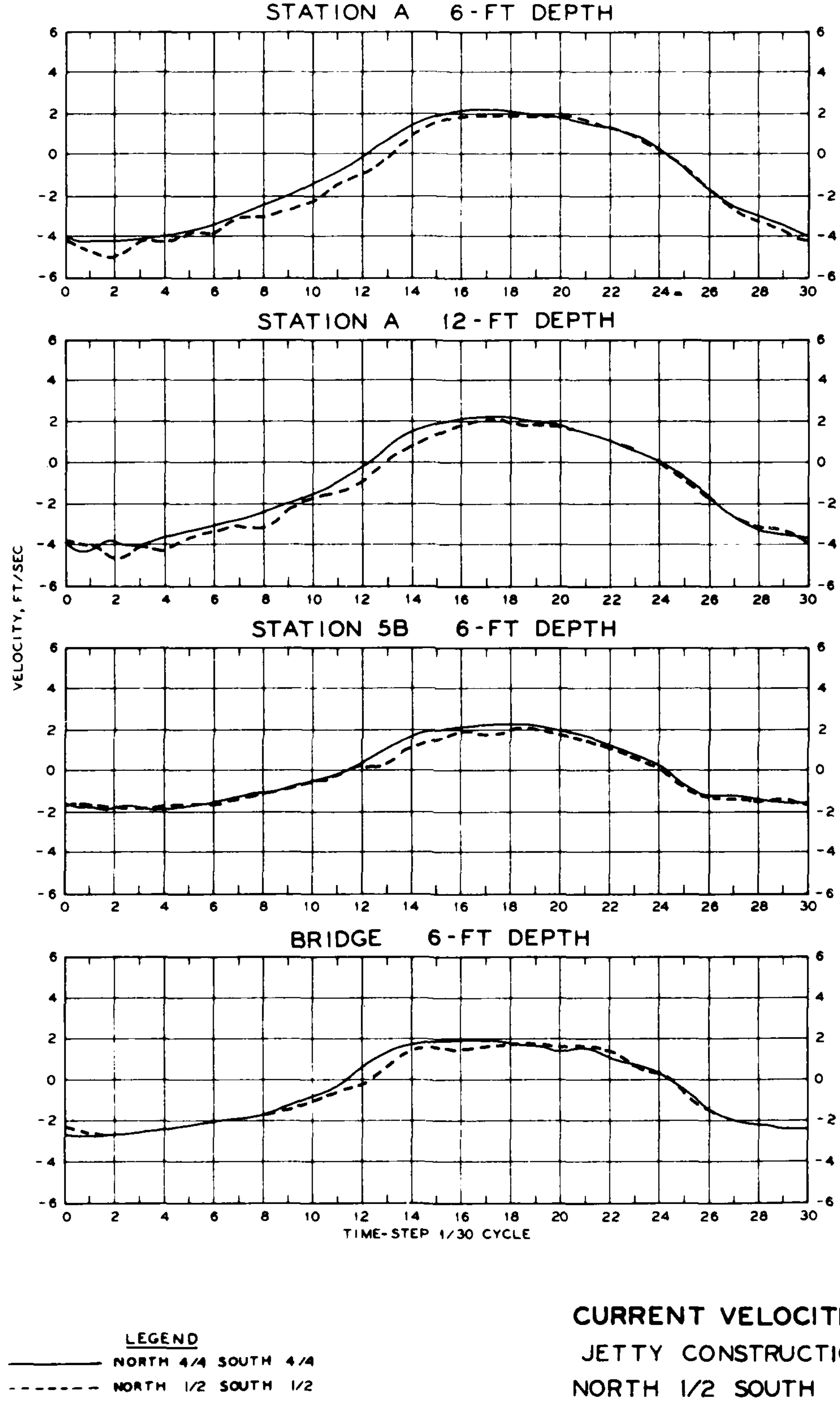
- - - - - NORTH 1/2 SOUTH 1/2

CURRENT VELOCITIES

JETTY CONSTRUCTION

NORTH 1/2 SOUTH 1/2

STATIONS 4B AND B

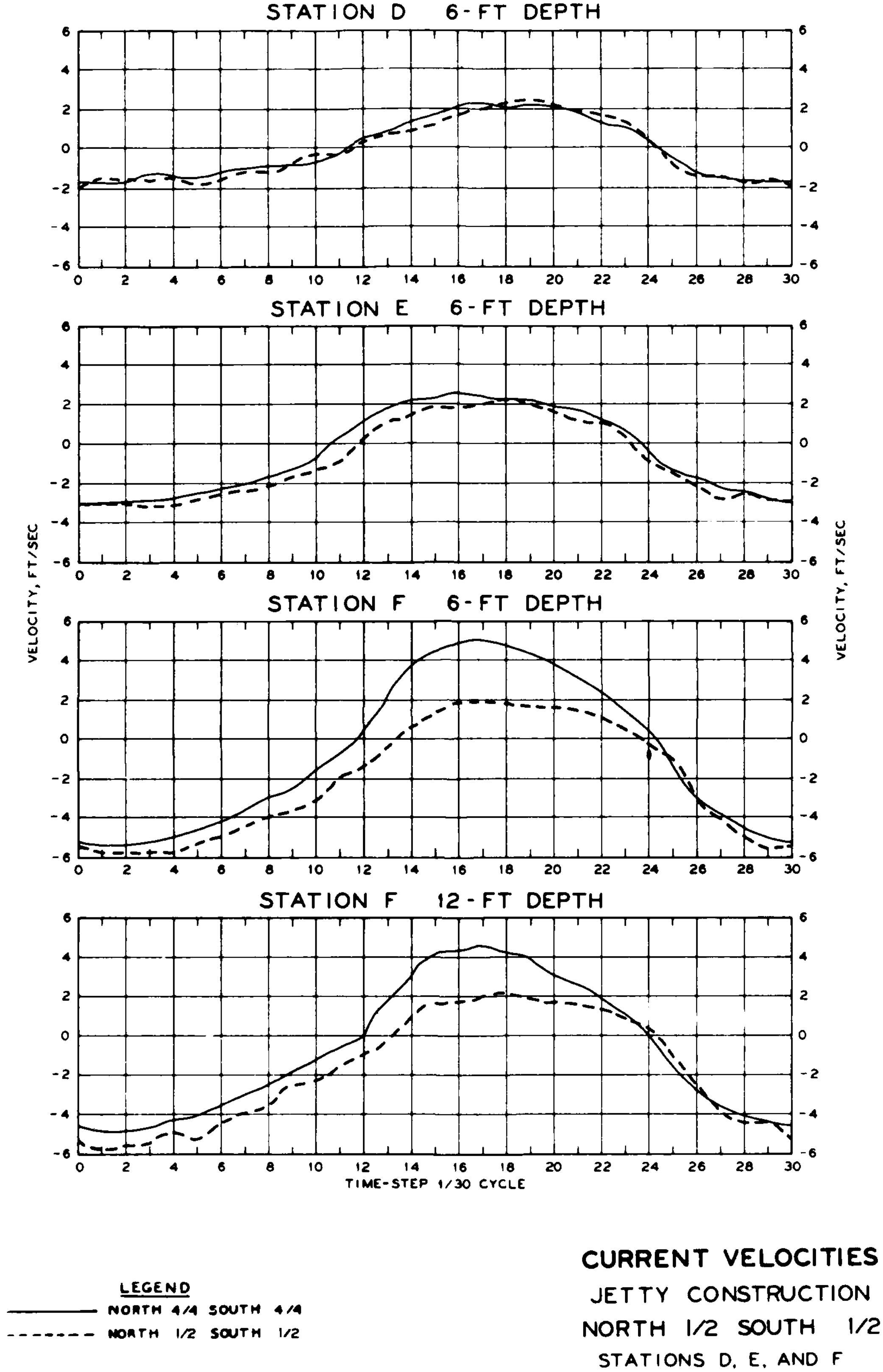


CURRENT VELOCITIES

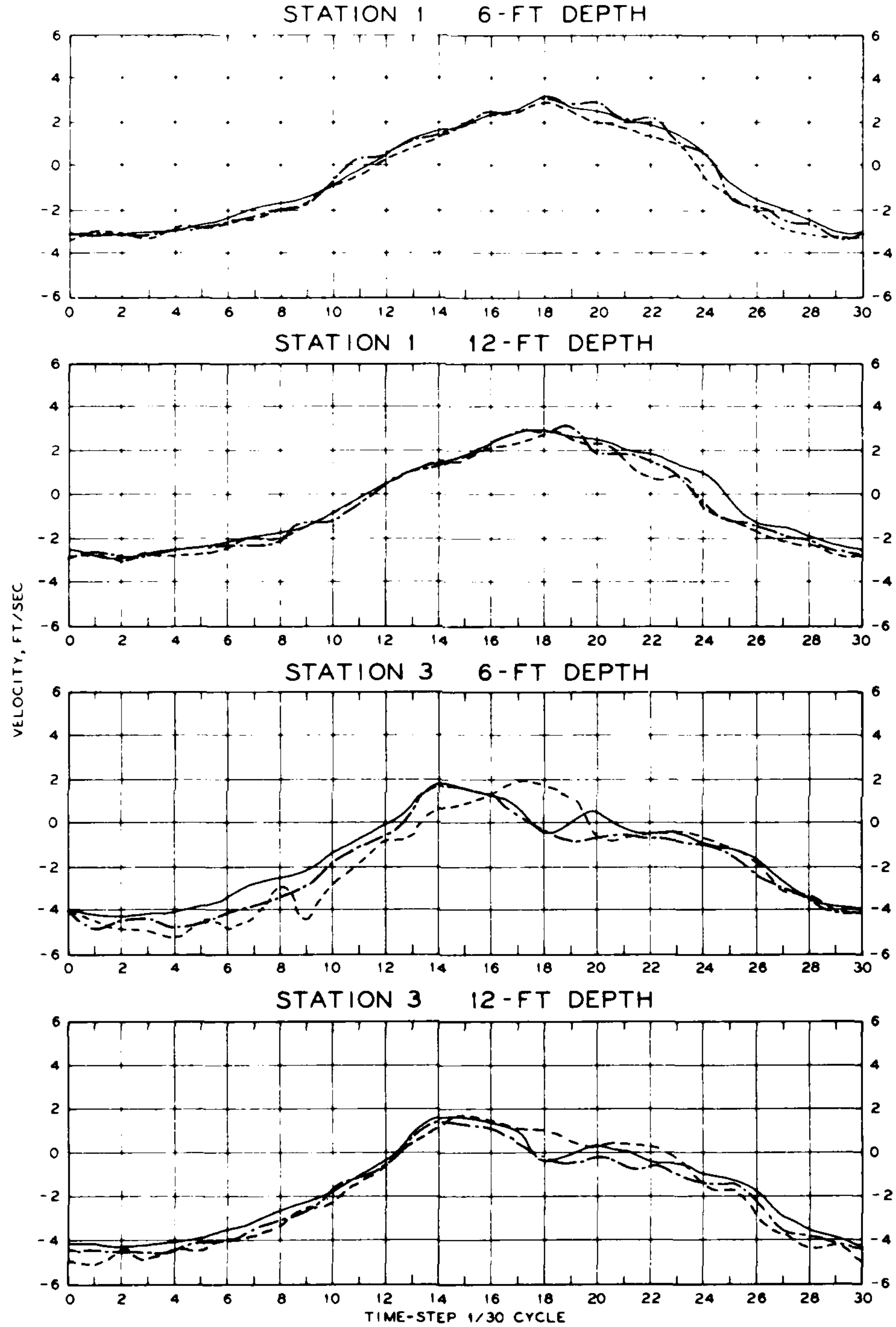
JETTY CONSTRUCTION

NORTH 1/2 SOUTH 1/2

STATIONS A, 5B, AND BRIDGE



CURRENT VELOCITIES
JETTY CONSTRUCTION
NORTH 1/2 SOUTH 1/2
STATIONS D, E, AND F



CURRENT VELOCITIES

JETTY CONSTRUCTION

NORTH 1/4 SOUTH 3/4

NORTH 3/4 SOUTH 3/4

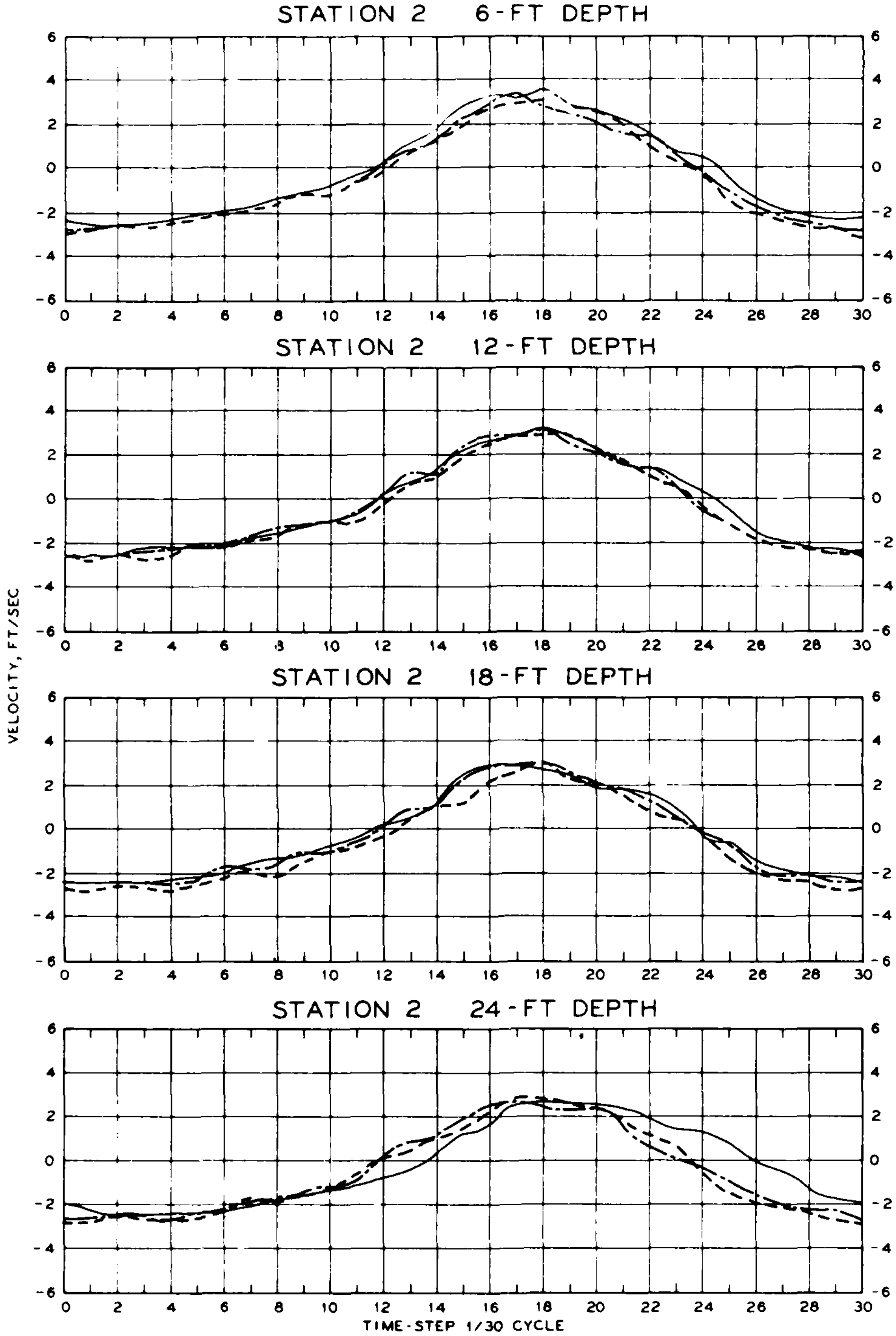
STATIONS 1 AND 3

LEGEND

NORTH 4/4 SOUTH 4/4

NORTH 1/4 SOUTH 3/4

NORTH 3/4 SOUTH 3/4



LEGEND

—————— NORTH 4/4 SOUTH 4/4

- - - - - - NORTH 1/4 SOUTH 3/4

— — — — NORTH 3/4 SOUTH 3/4

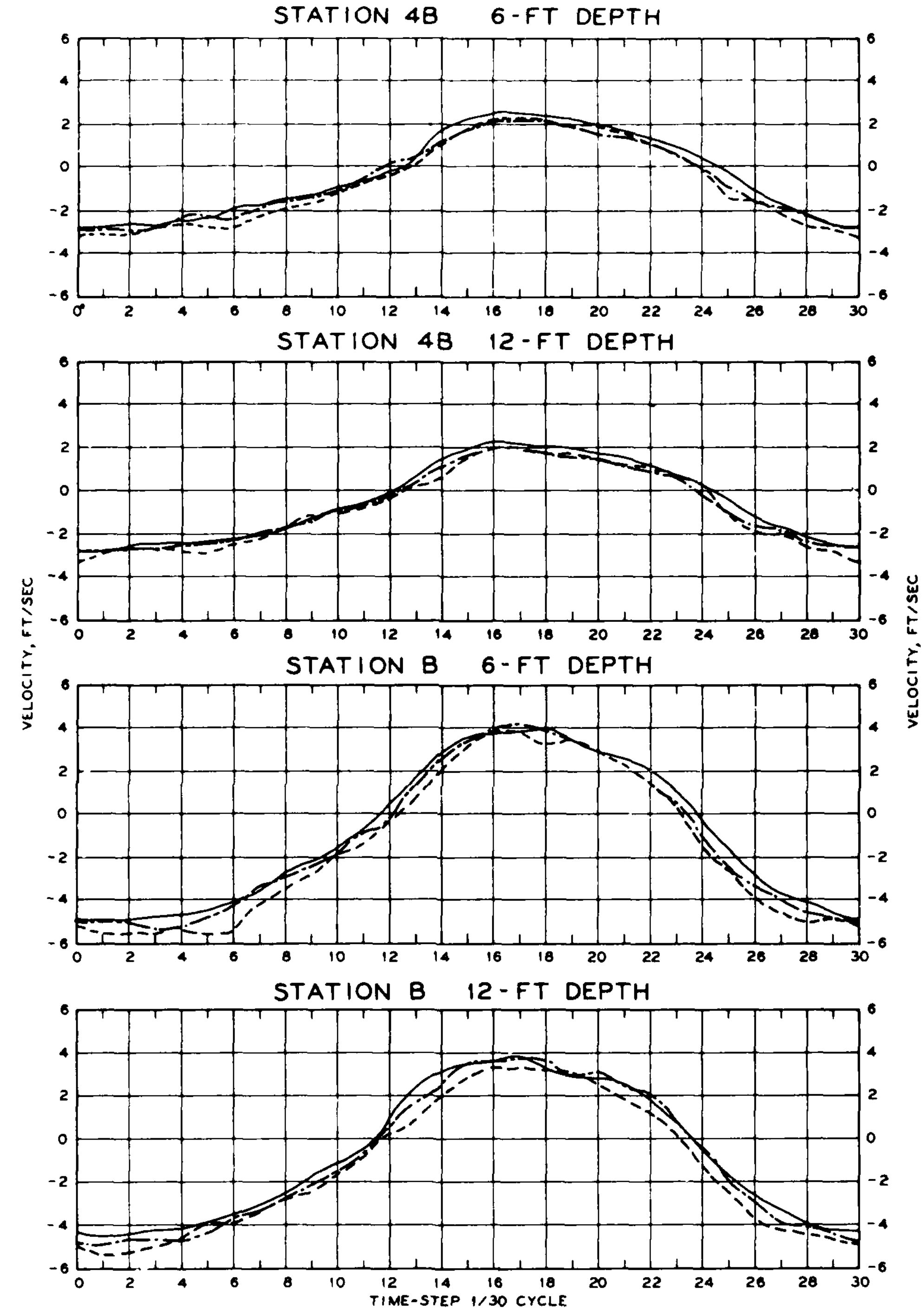
CURRENT VELOCITIES

JETTY CONSTRUCTION

NORTH 1/4 SOUTH 3/4

NORTH 3/4 SOUTH 3/4

STATION 2



LEGEND

- ——— NORTH 4/4 SOUTH 4/4
- - - - - - NORTH 1/4 SOUTH 3/4
- — — -·- - NORTH 3/4 SOUTH 3/4

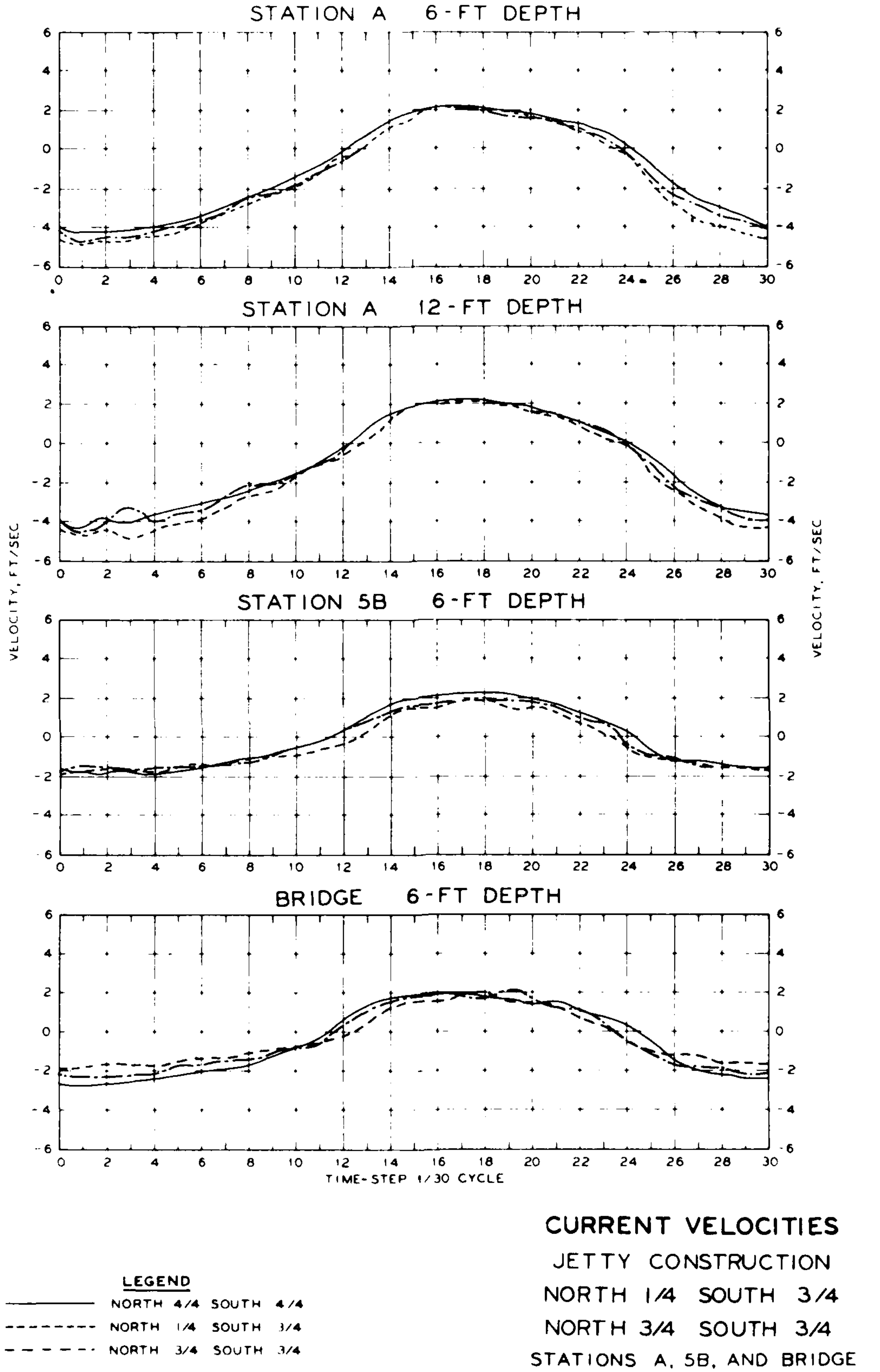
CURRENT VELOCITIES

JETTY CONSTRUCTION

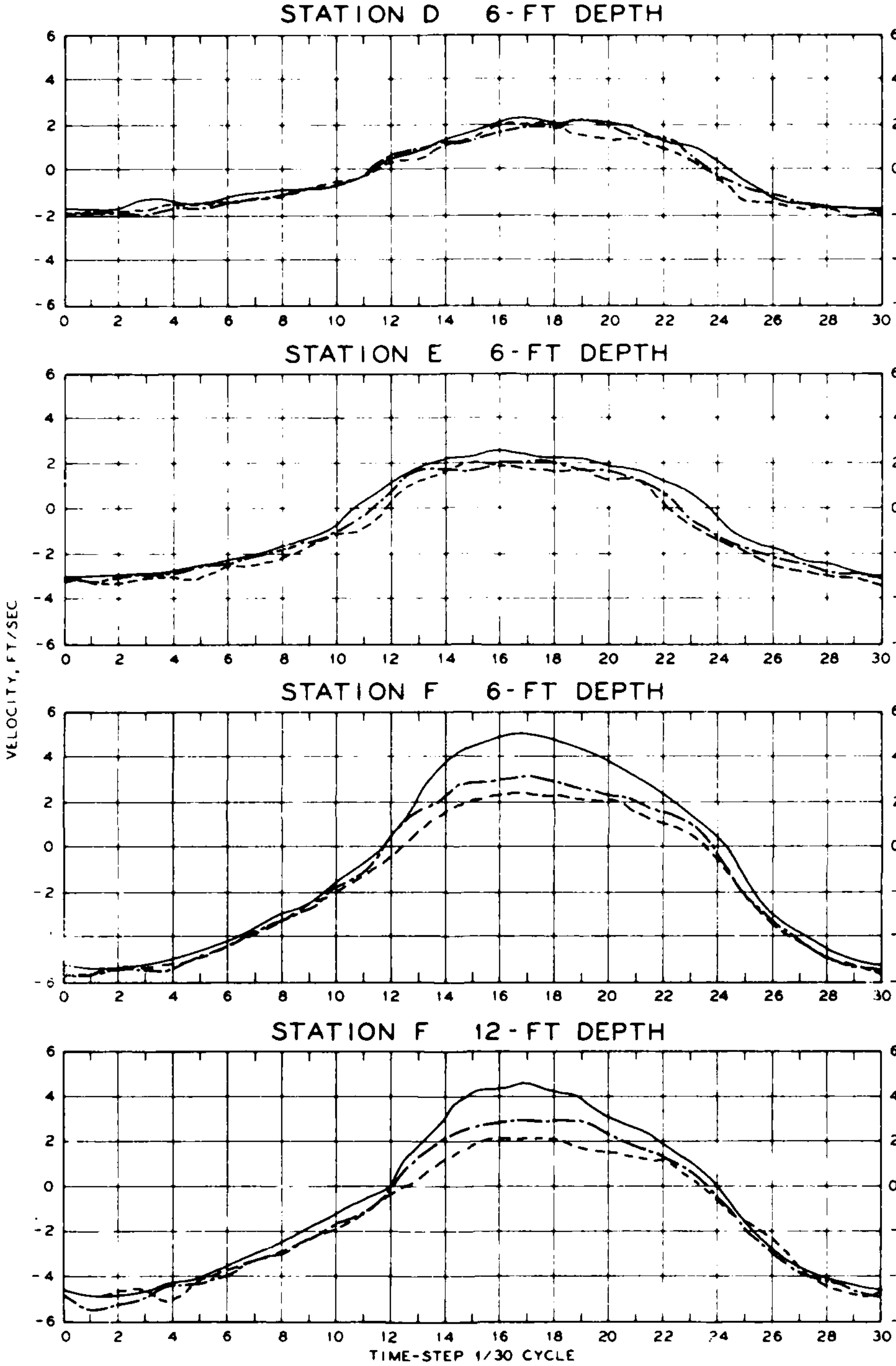
NORTH 1/4 SOUTH 3/4

NORTH 3/4 SOUTH 3/4

STATIONS 4B AND B



CURRENT VELOCITIES
JETTY CONSTRUCTION
NORTH 1/4 SOUTH 3/4
NORTH 3/4 SOUTH 3/4
STATIONS A, 5B, AND BRIDGE



LEGEND

———	NORTH 4/4 SOUTH 4/4
- - - - - -	NORTH 1/4 SOUTH 3/4
— — - — —	NORTH 3/4 SOUTH 3/4

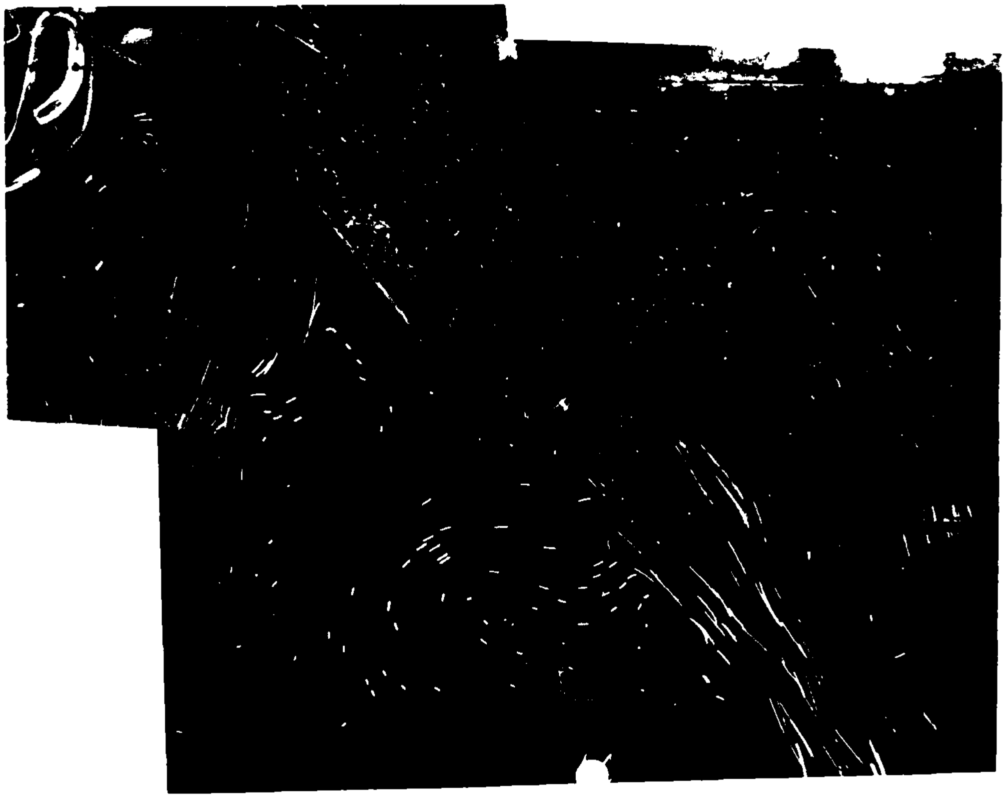
CURRENT VELOCITIES

JETTY CONSTRUCTION

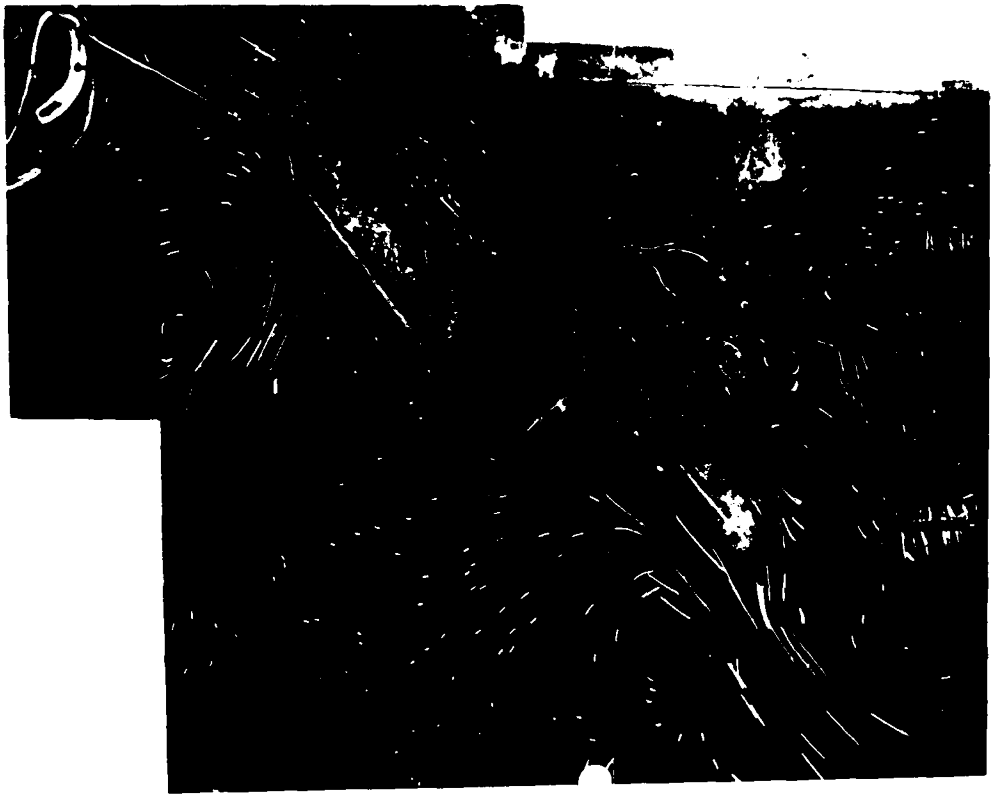
NORTH 1/4 SOUTH 3/4

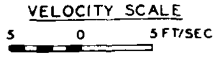
NORTH 3/4 SOUTH 3/4

STATIONS D, E, AND F

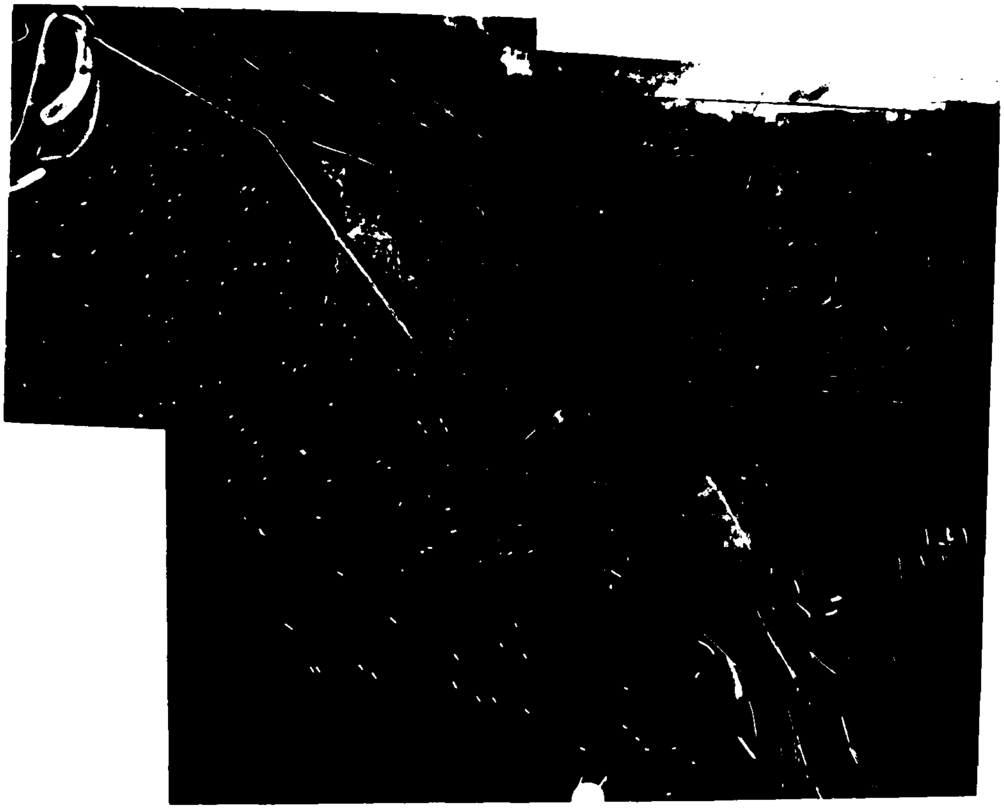


SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
BASE
TIME-STEP 16



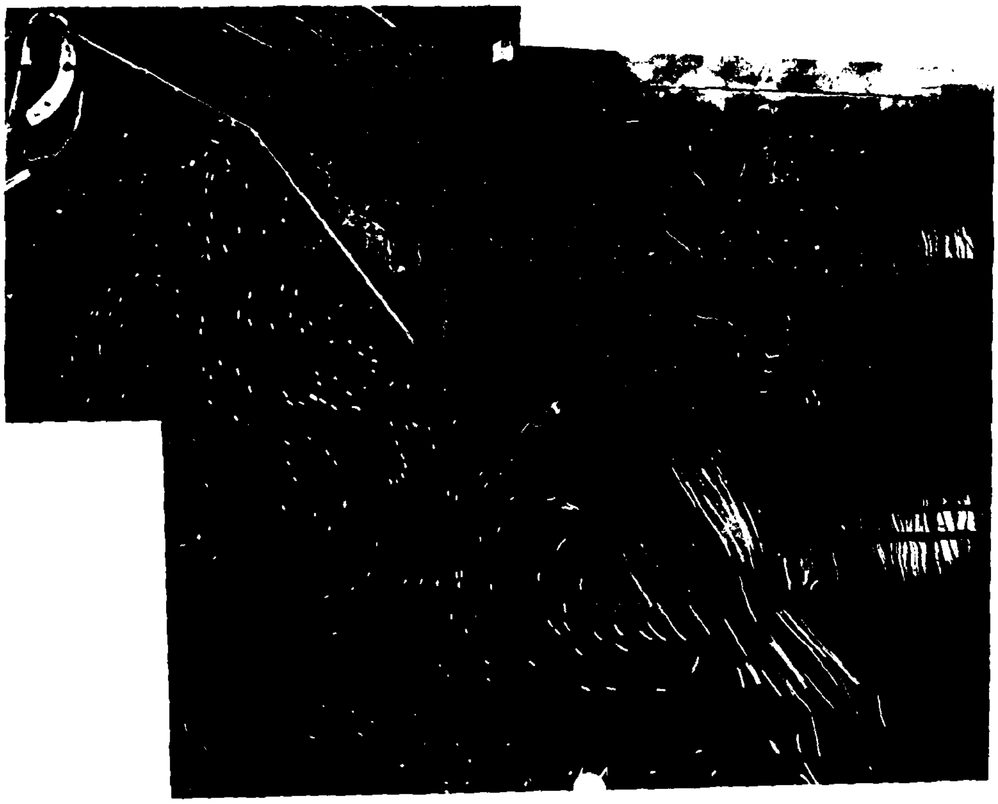


SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 0 COMPLETE
SOUTH JETTY 1/4 COMPLETE
TIME-STEP 16



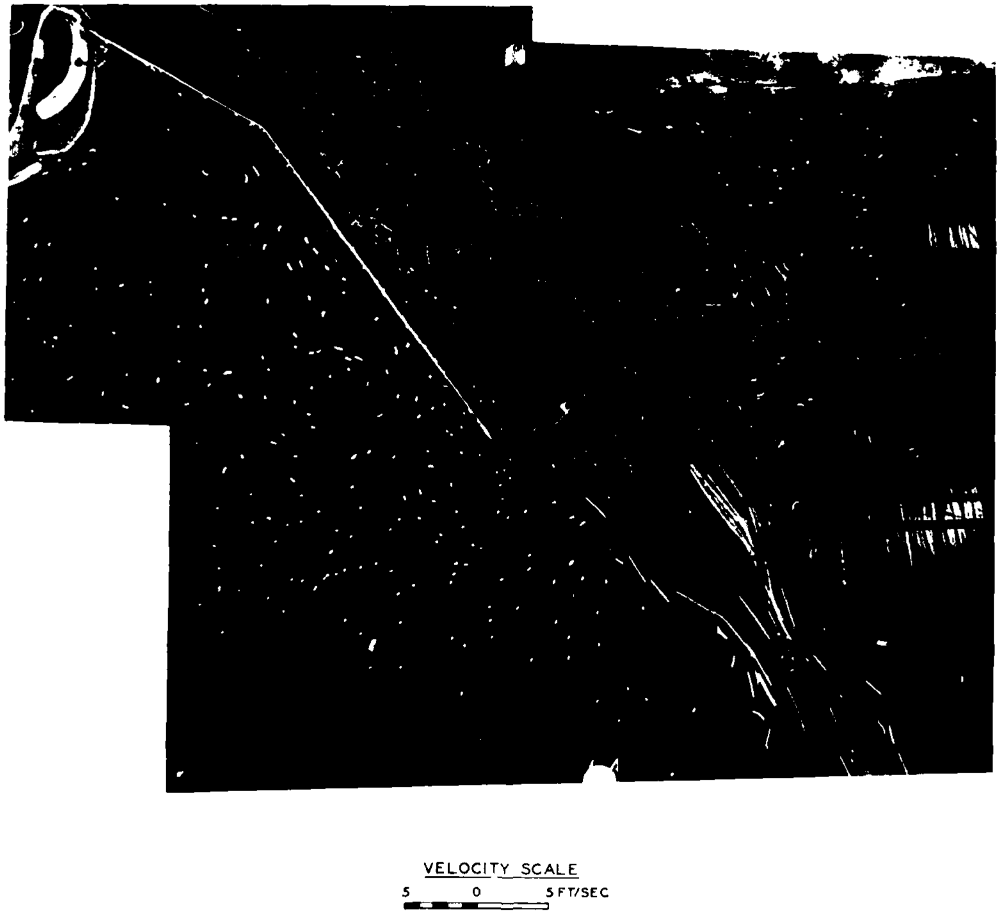
VELOCITY SCALE
5 0 5 FT/SEC

SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 0 COMPLETE
SOUTH JETTY 1/2 COMPLETE
TIME-STEP 16

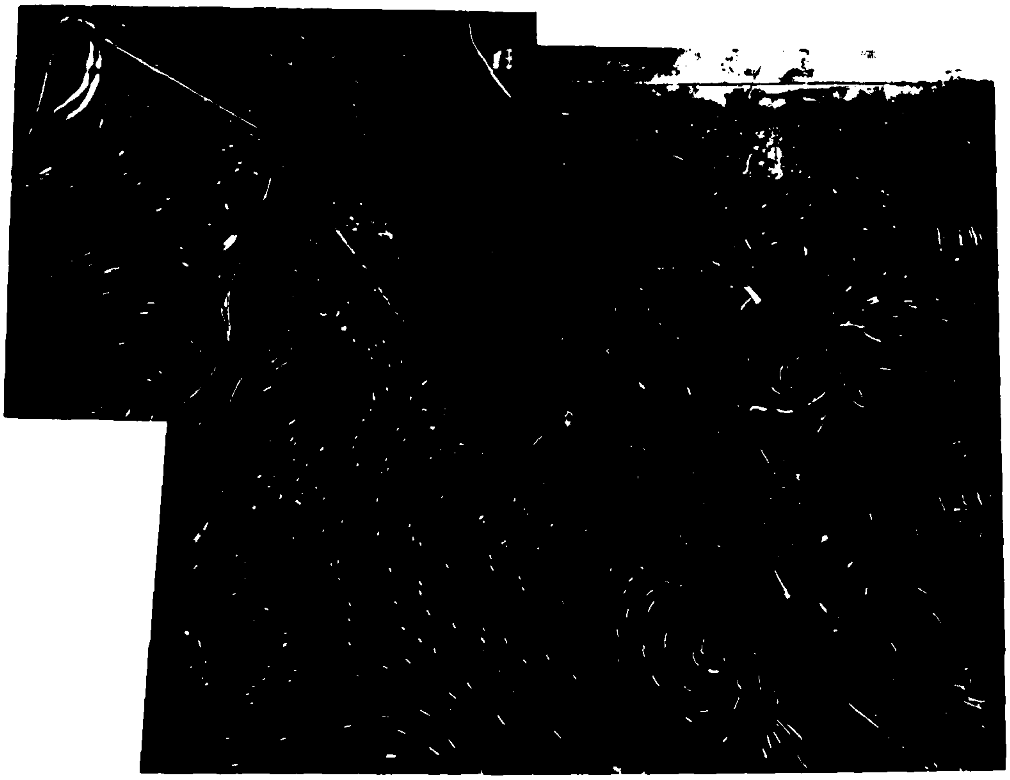


VELOCITY SCALE
5 0 5 FT/SEC

SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 0 COMPLETE
SOUTH JETTY 3/4 COMPLETE
TIME-STEP 16



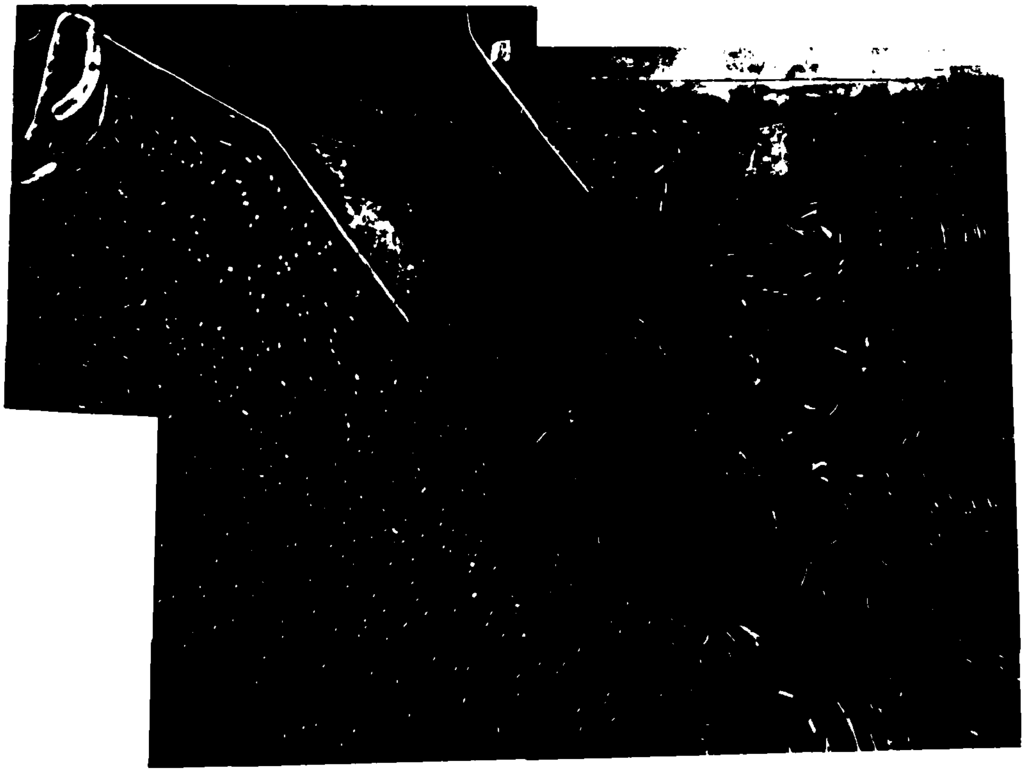
SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 0 COMPLETE
SOUTH JETTY 4/4 COMPLETE
TIME-STEP 16

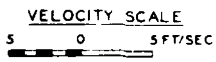


VELOCITY SCALE

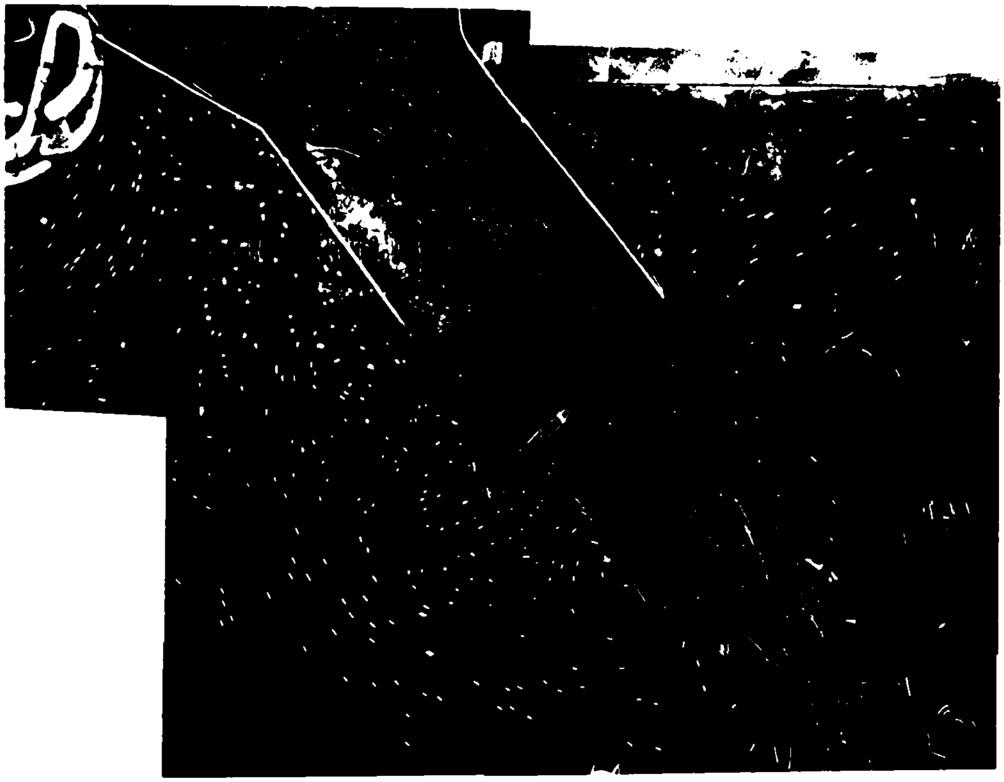
5 0 5 FT/SEC

SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 1/4 COMPLETE
SOUTH JETTY 1/4 COMPLETE
TIME-STEP 16

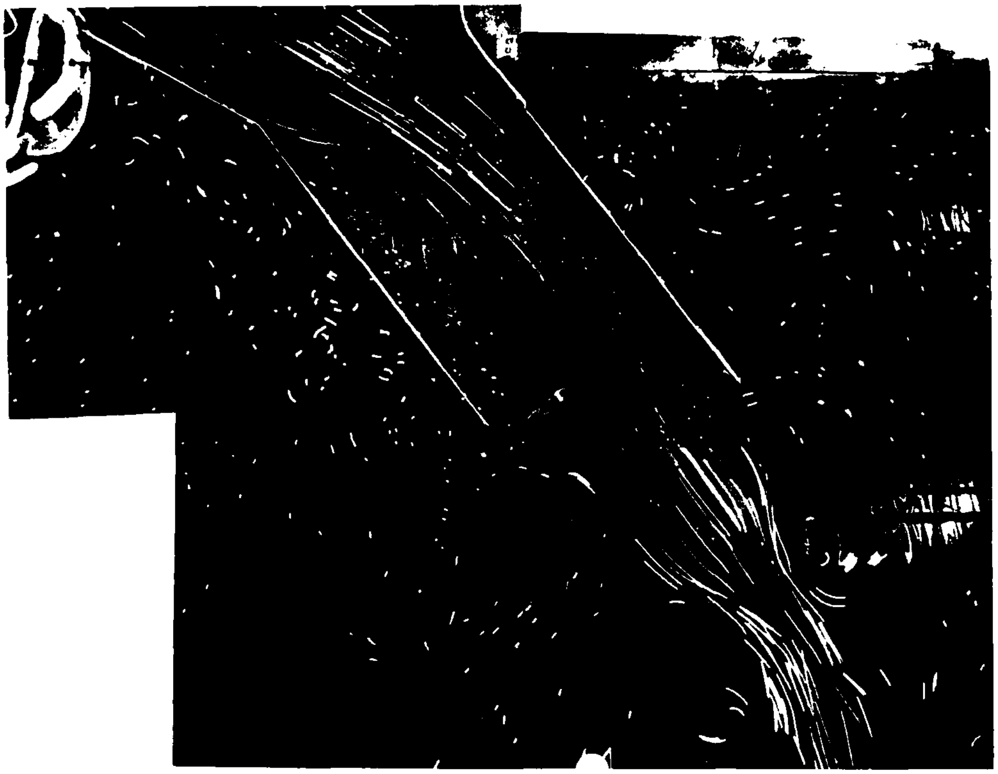




SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 1/2 COMPLETE
SOUTH JETTY 1/2 COMPLETE
TIME-STEP 16



SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 3/4 COMPLETE
SOUTH JETTY 3/4 COMPLETE
TIME-STEP 16



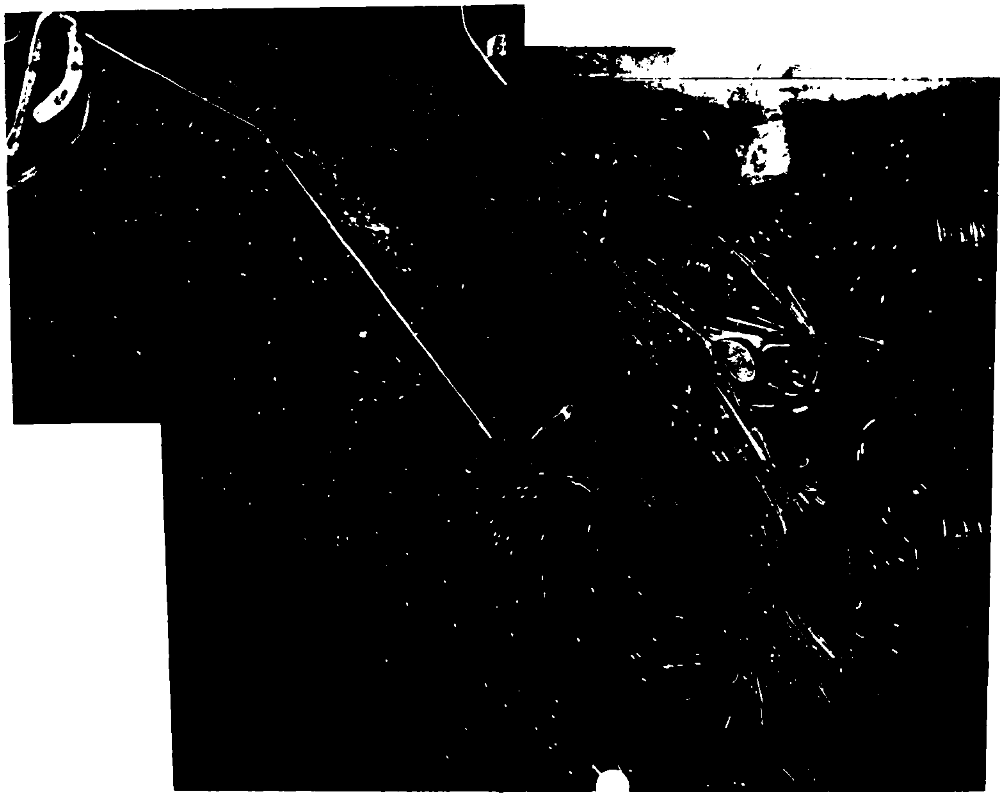
VELOCITY SCALE

5 0 5 FT/SEC

SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 4/4 COMPLETE
SOUTH JETTY 4/4 COMPLETE
TIME-STEP 16

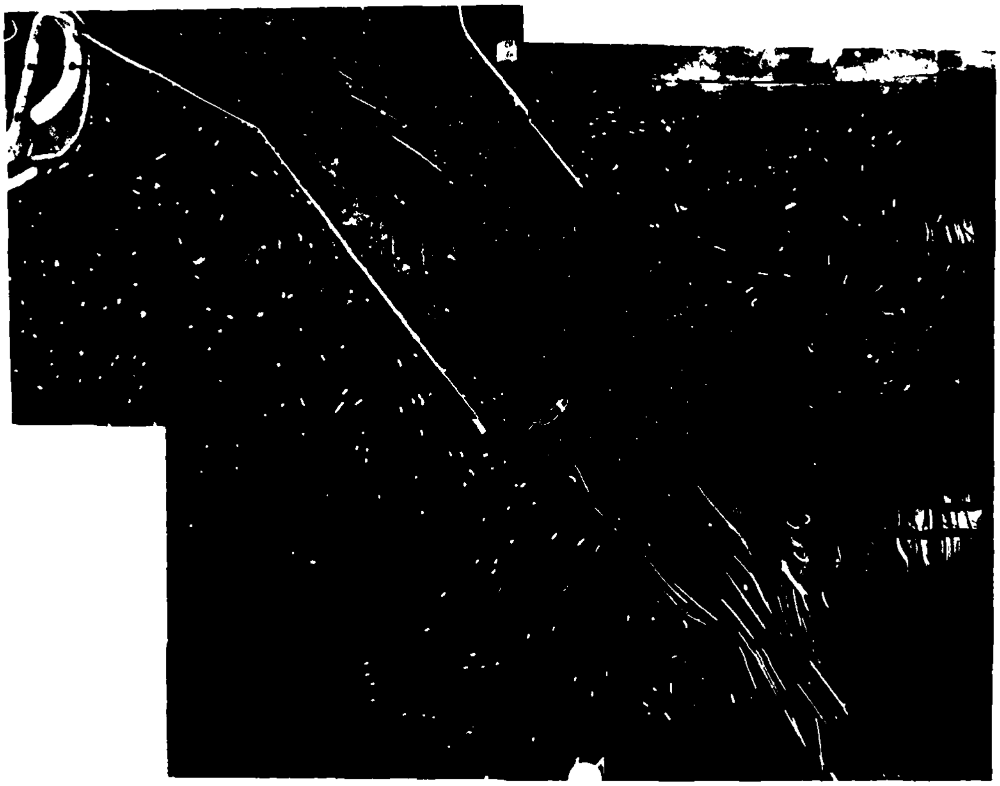
VELOCITY SCALE
5 0 5 FT/SEC

SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 1/4 COMPLETE
SOUTH JETTY 3/4 COMPLETE
TIME-STEP 16



VELOCITY SCALE
5 0 5 FT/SEC

SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 1/4 COMPLETE
SOUTH JETTY 4/4 COMPLETE
TIME-STEP 16



VELOCITY SCALE
5 0 5 FT/SEC

SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 1/2 COMPLETE
SOUTH JETTY 4/4 COMPLETE
TIME-STEP 16

SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 4/4 COMPLETE
SOUTH JETTY 3/4 COMPLETE
TIME-STEP 16

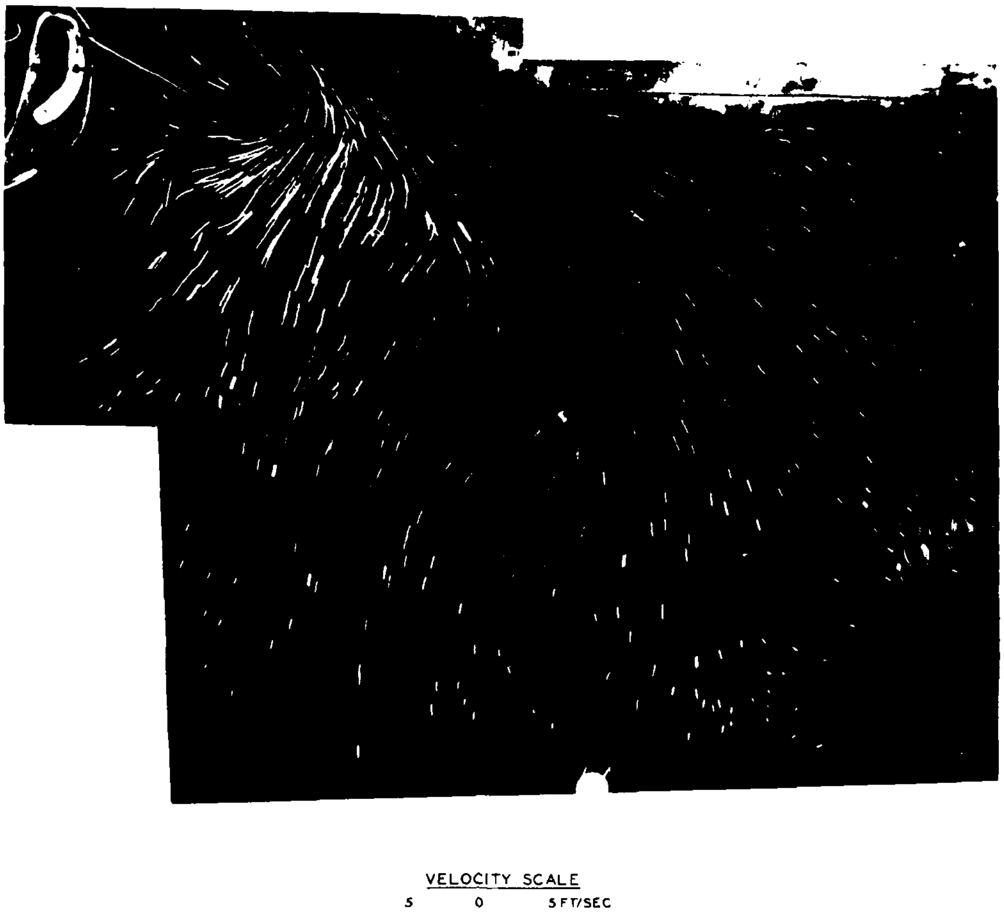
VELOCITY SCALE

5 0 5 FT/SEC

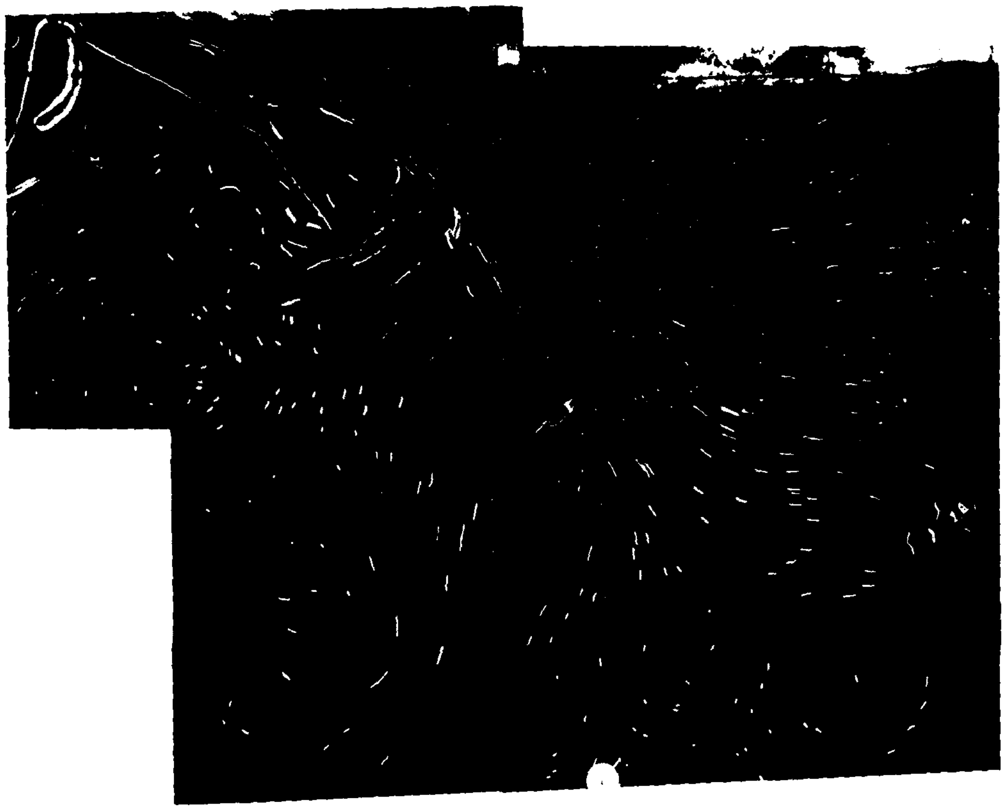
SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS

BASE

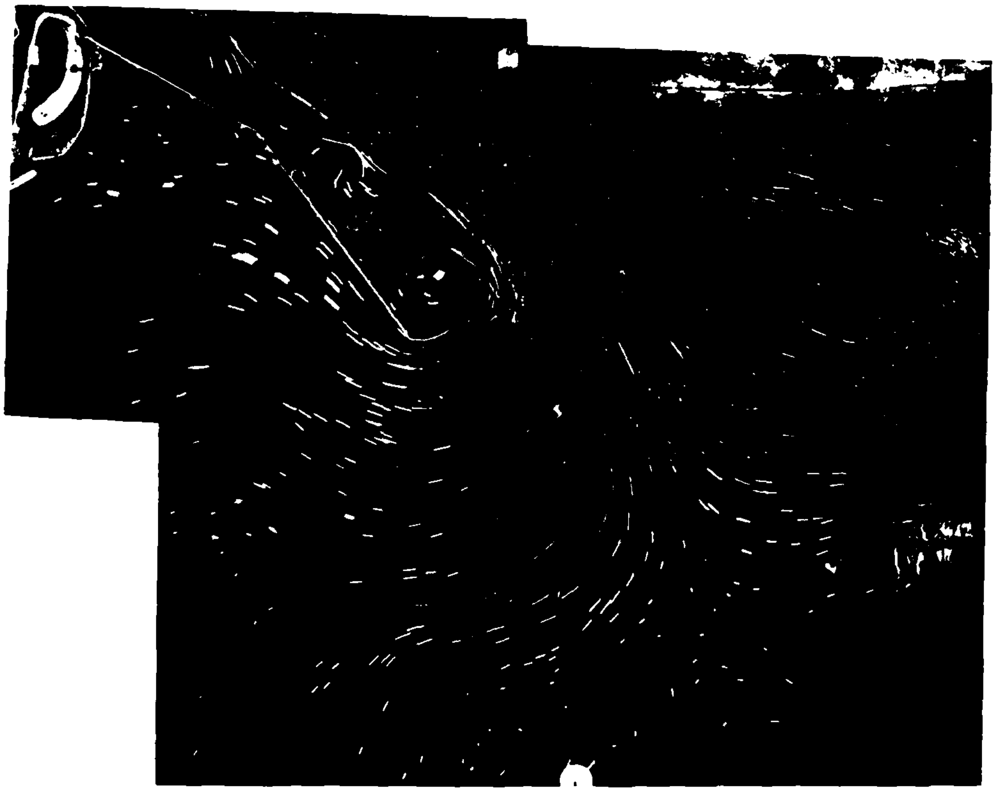
TIME-STEP 1



SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 0 COMPLETE
SOUTH JETTY 1/4 COMPLETE
TIME-STEP 1



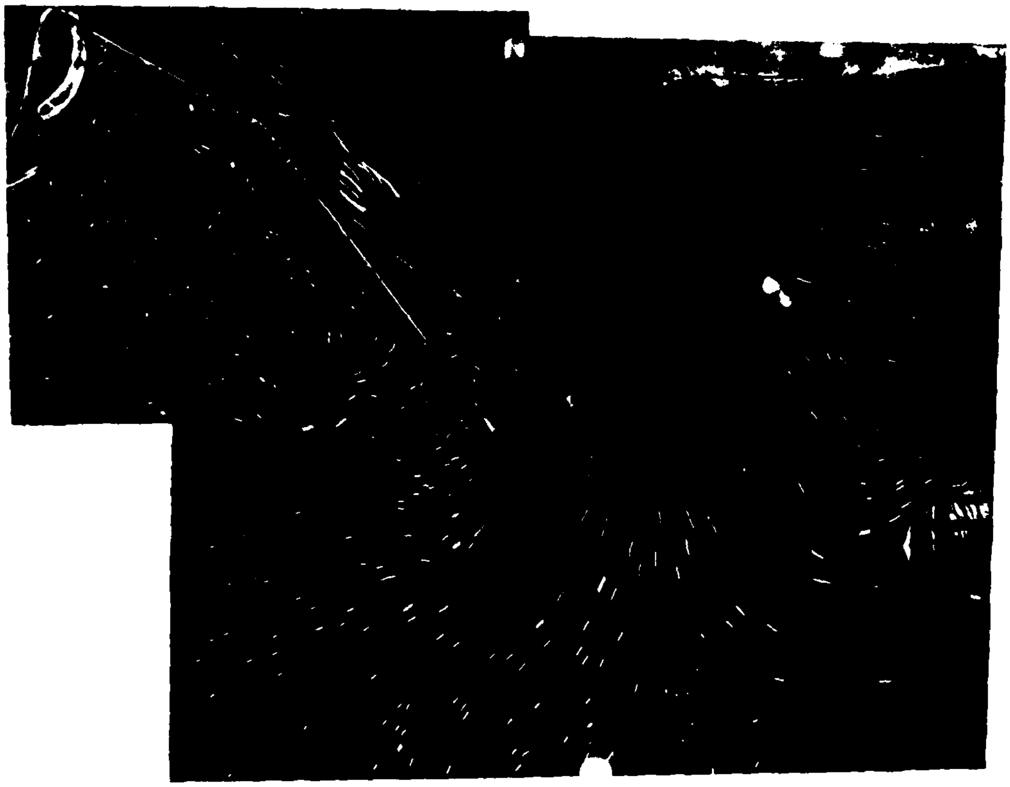
SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 0 COMPLETE
SOUTH JETTY 1/2 COMPLETE
TIME-STEP 1



VELOCITY SCALE

5 0 5 FT/SEC

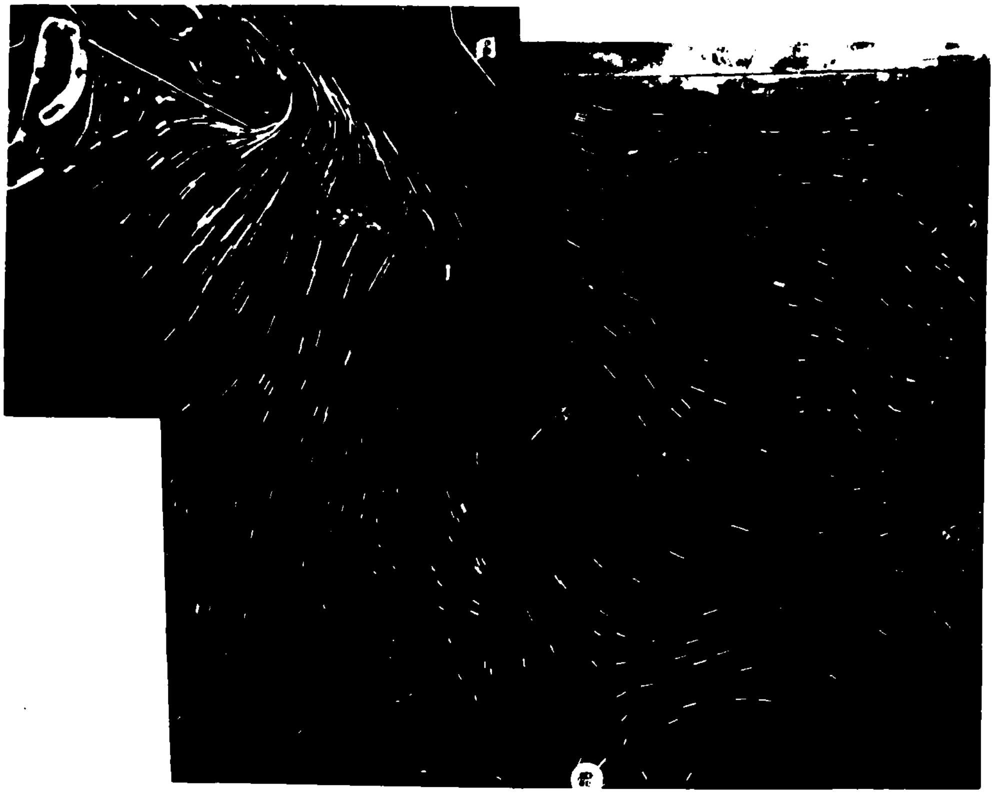
SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 0 COMPLETE
SOUTH JETTY 3/4 COMPLETE
TIME-STEP 1



VELOCITY SCALE
5 0 5 FT/SEC

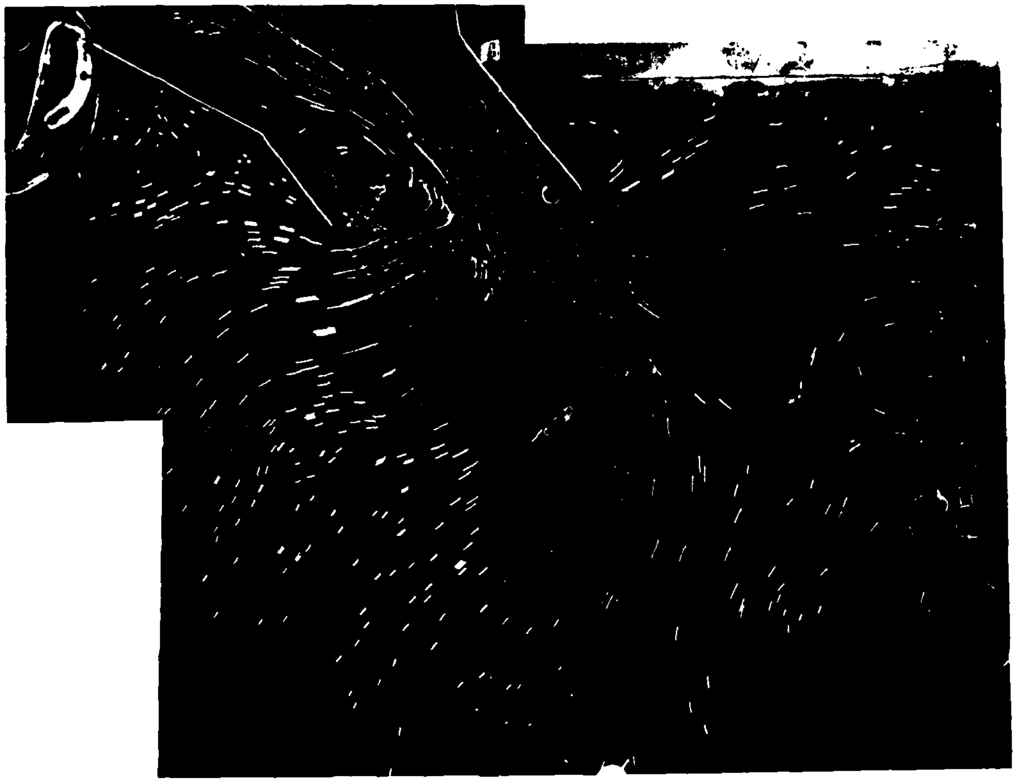
SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 0 COMPLETE
SOUTH JETTY 4/4 COMPLETE
TIME-STEP 1

PLATE 332



VELOCITY SCALE
5 0 5 FT/SEC

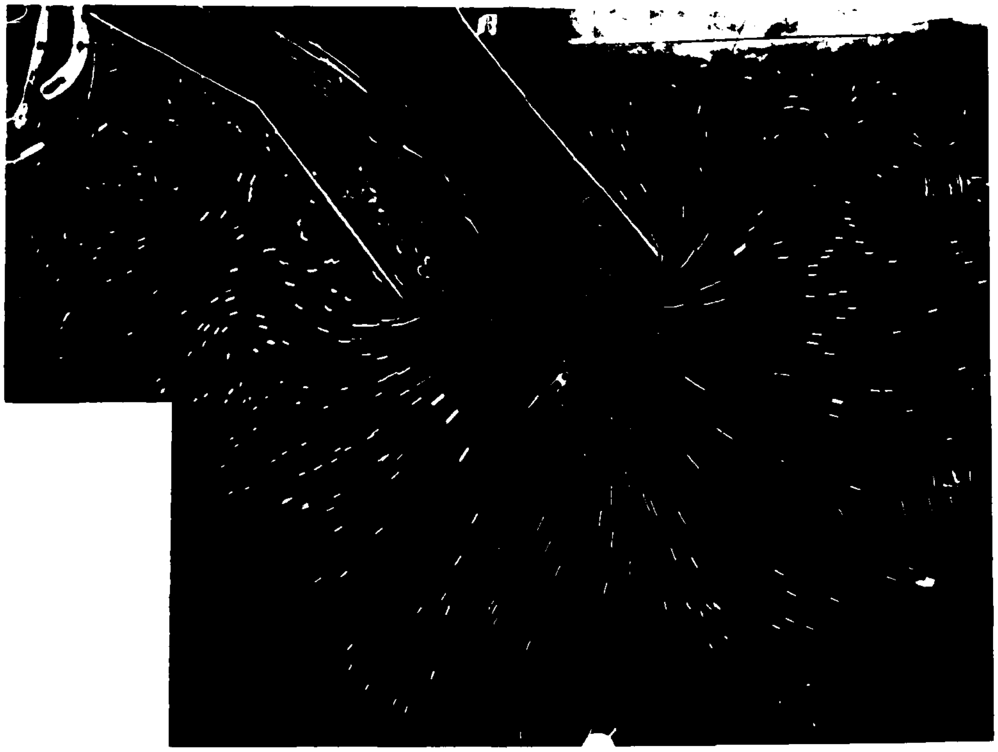
SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 1/4 COMPLETE
SOUTH JETTY 1/4 COMPLETE
TIME-STEP 1



VELOCITY SCALE

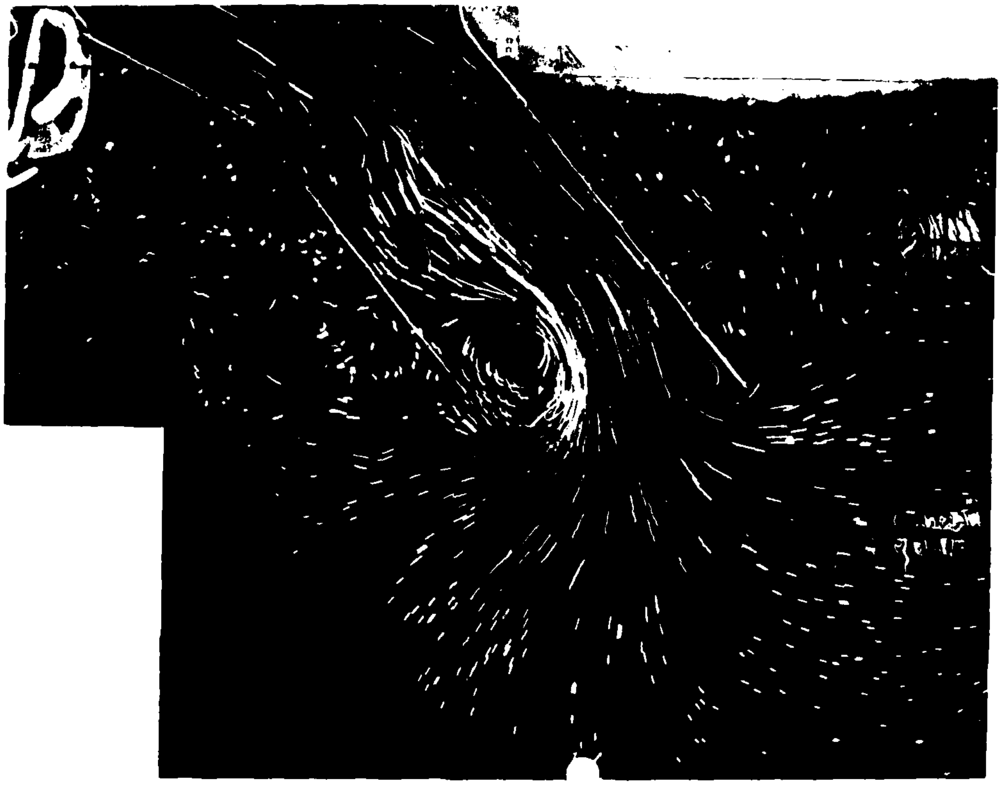
5 0 5 FT/SEC

SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 1/2 COMPLETE
SOUTH JETTY 1/2 COMPLETE
TIME-STEP 1



VELOCITY SCALE
5 0 5 FT/SEC

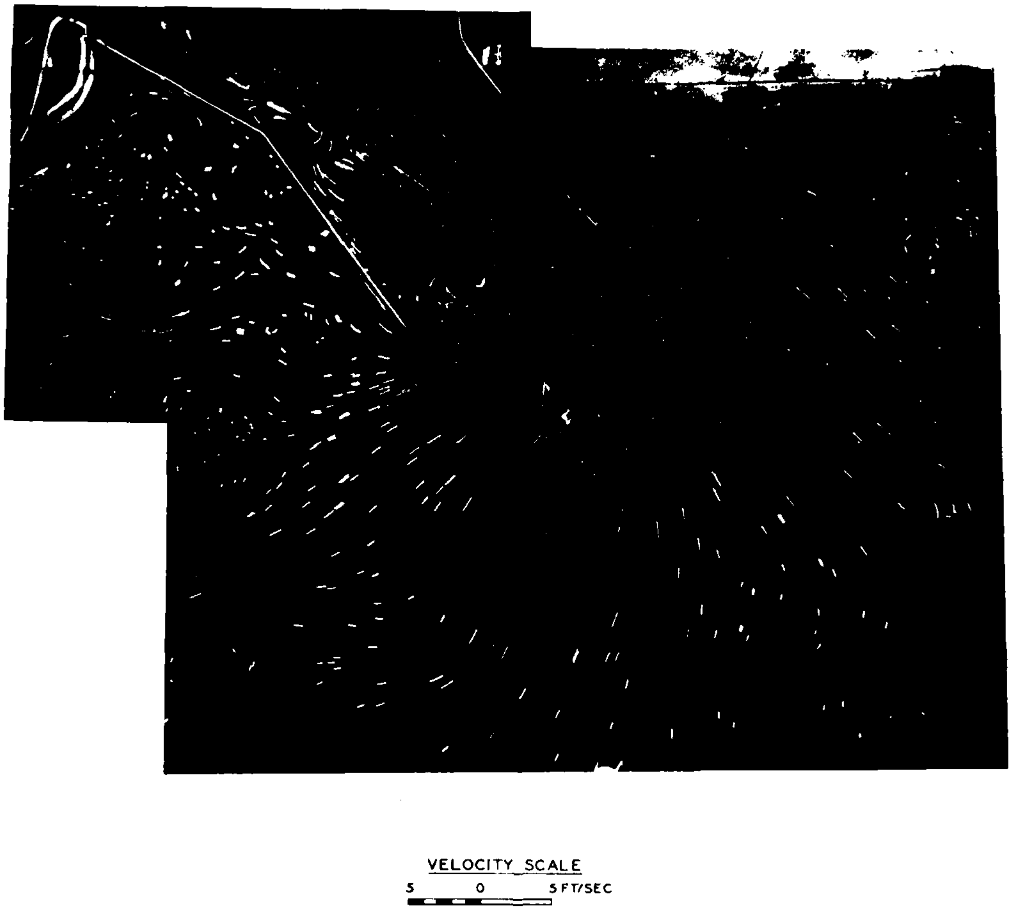
SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 3/4 COMPLETE
SOUTH JETTY 3/4 COMPLETE
TIME-STEP 1



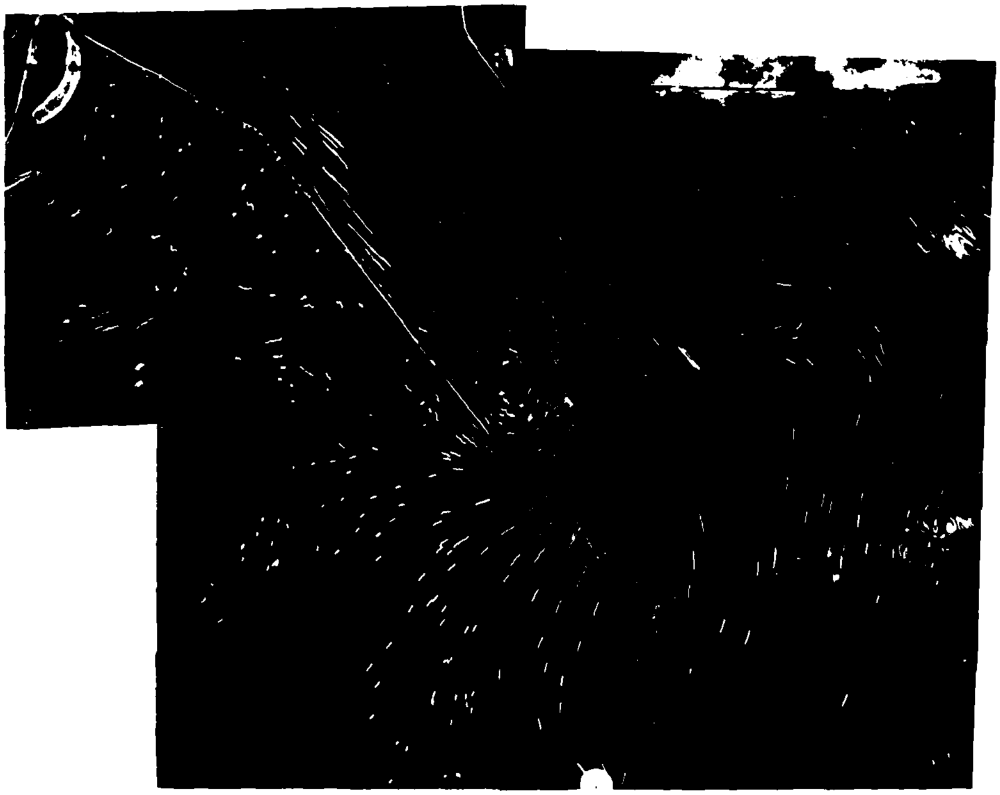
VELOCITY SCALE

5 0 5 FT/SEC

SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 4/4 COMPLETE
SOUTH JETTY 4/4 COMPLETE
TIME-STEP 1

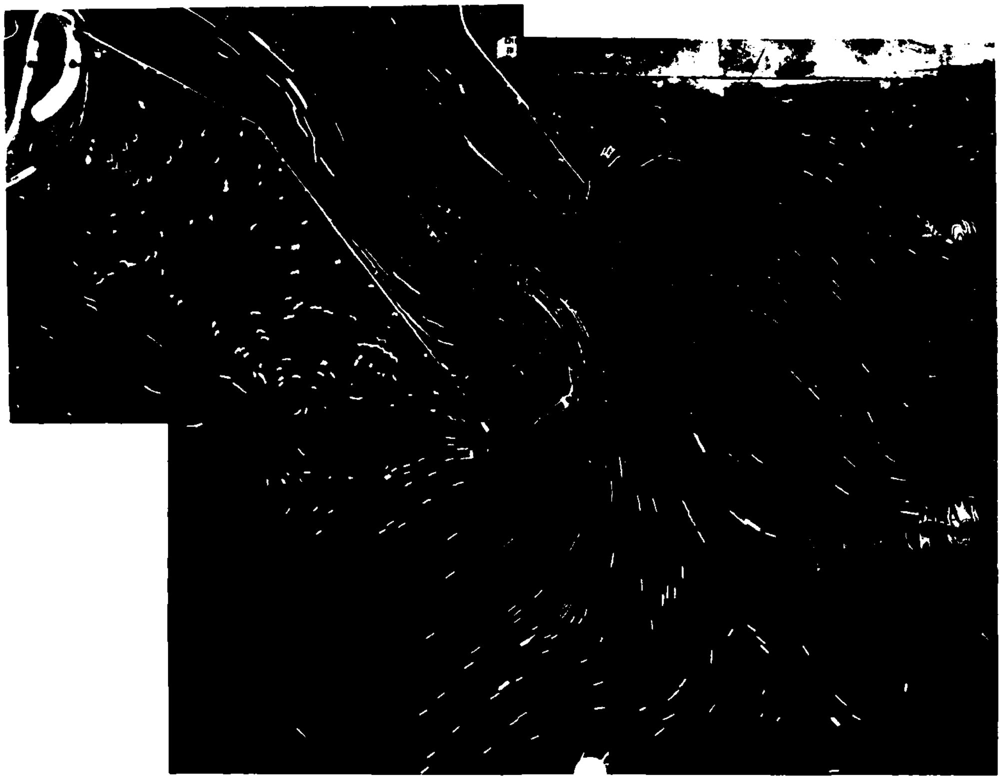


SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 1/4 COMPLETE
SOUTH JETTY 3/4 COMPLETE
TIME-STEP 1

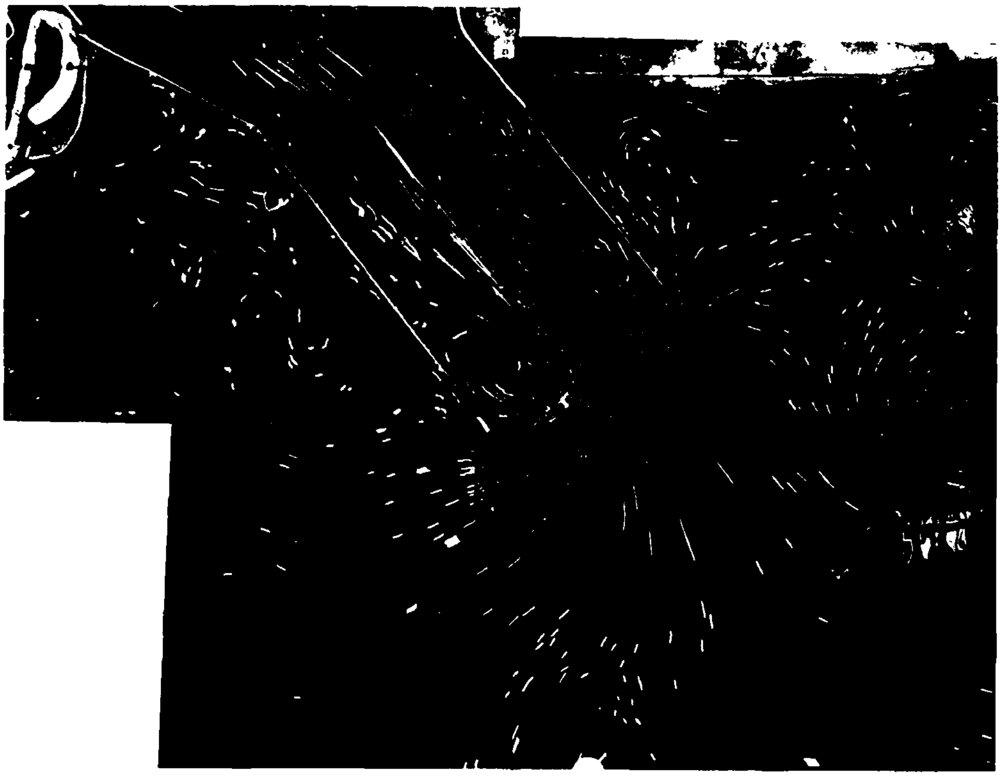


VELOCITY SCALE
5 0 5 FT/SEC

SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 1/4 COMPLETE
SOUTH JETTY 4/4 COMPLETE
TIME-STEP 1



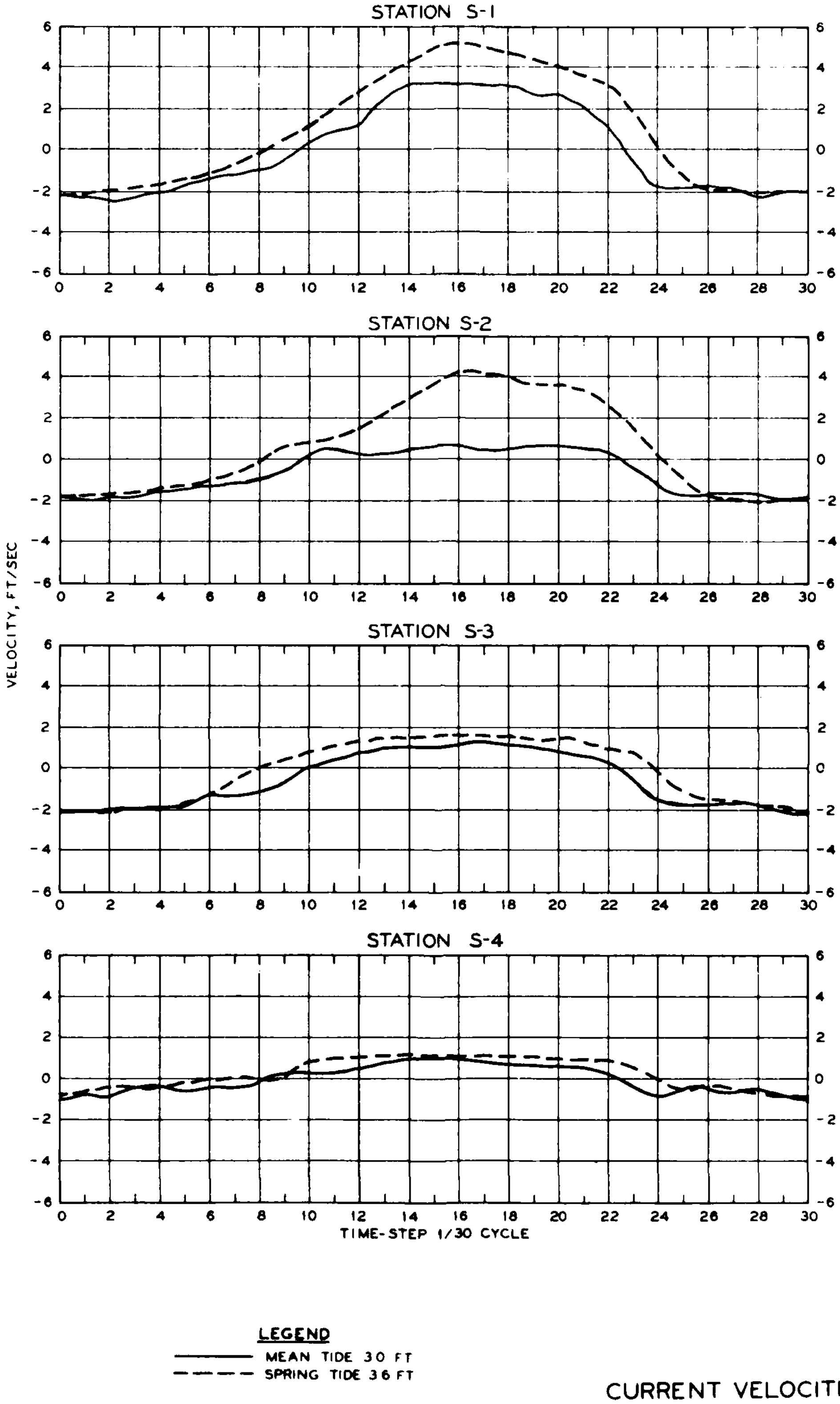
SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 1/2 COMPLETE
SOUTH JETTY 4/4 COMPLETE
TIME-STEP 1



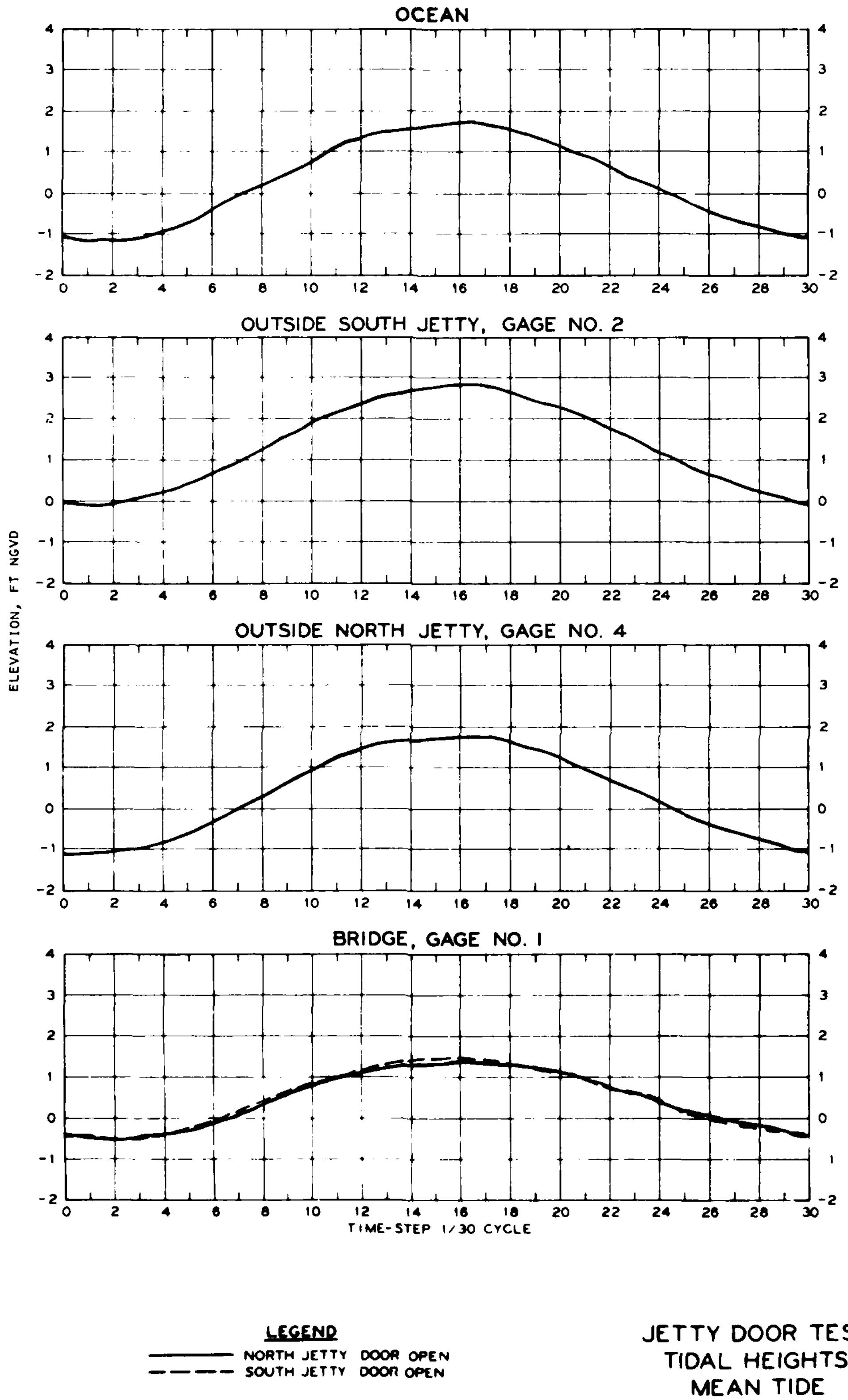
VELOCITY SCALE

5 0 5 FT/SEC

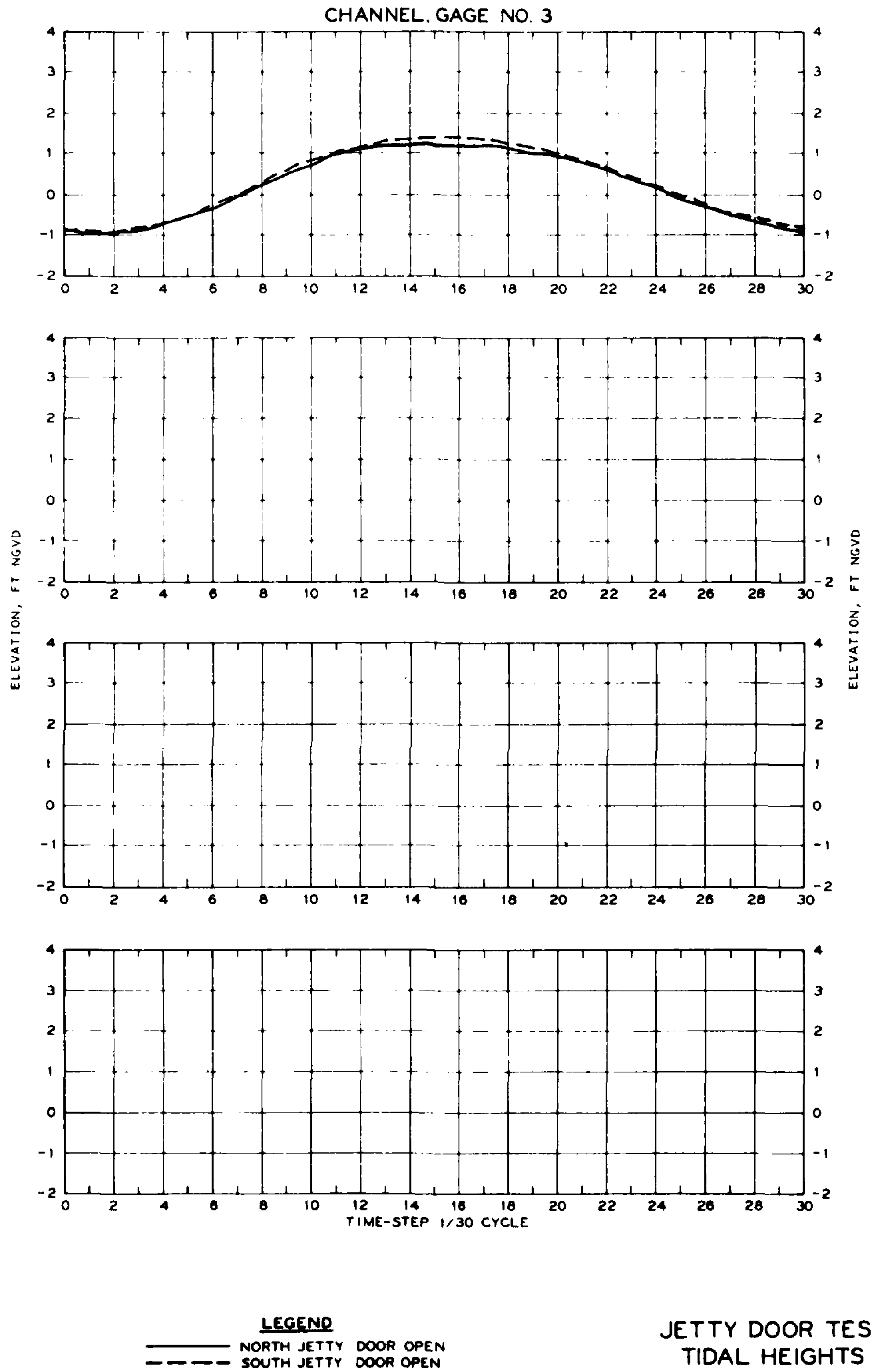
SURFACE CURRENT PHOTOGRAPHS
STAGE JETTY CONSTRUCTION TESTS
NORTH JETTY 4/4 COMPLETE
SOUTH JETTY 3/4 COMPLETE
TIME-STEP 1



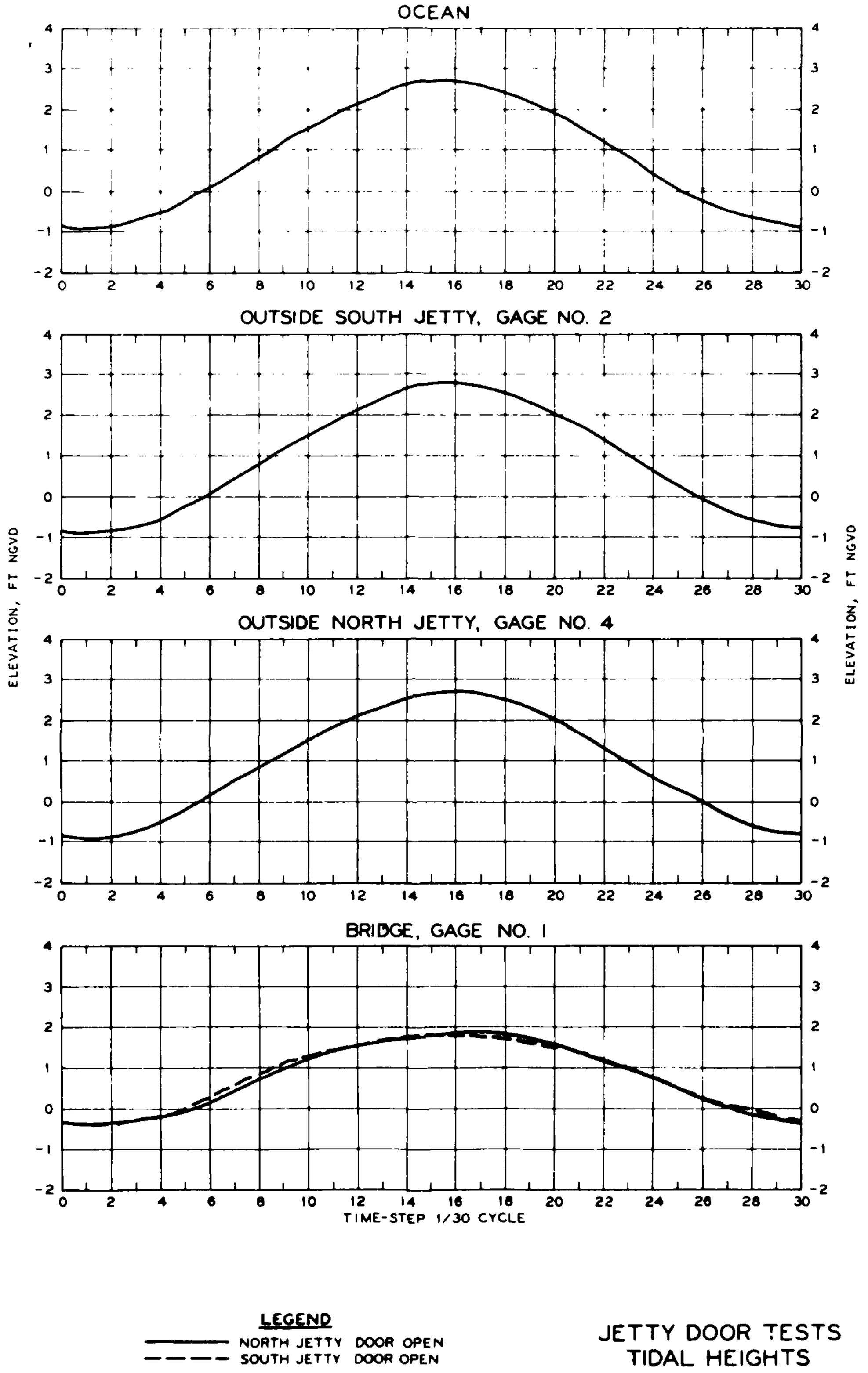
CURRENT VELOCITIES
JETTY DOOR TEST
STATIONS S1, S2, S3, AND S4



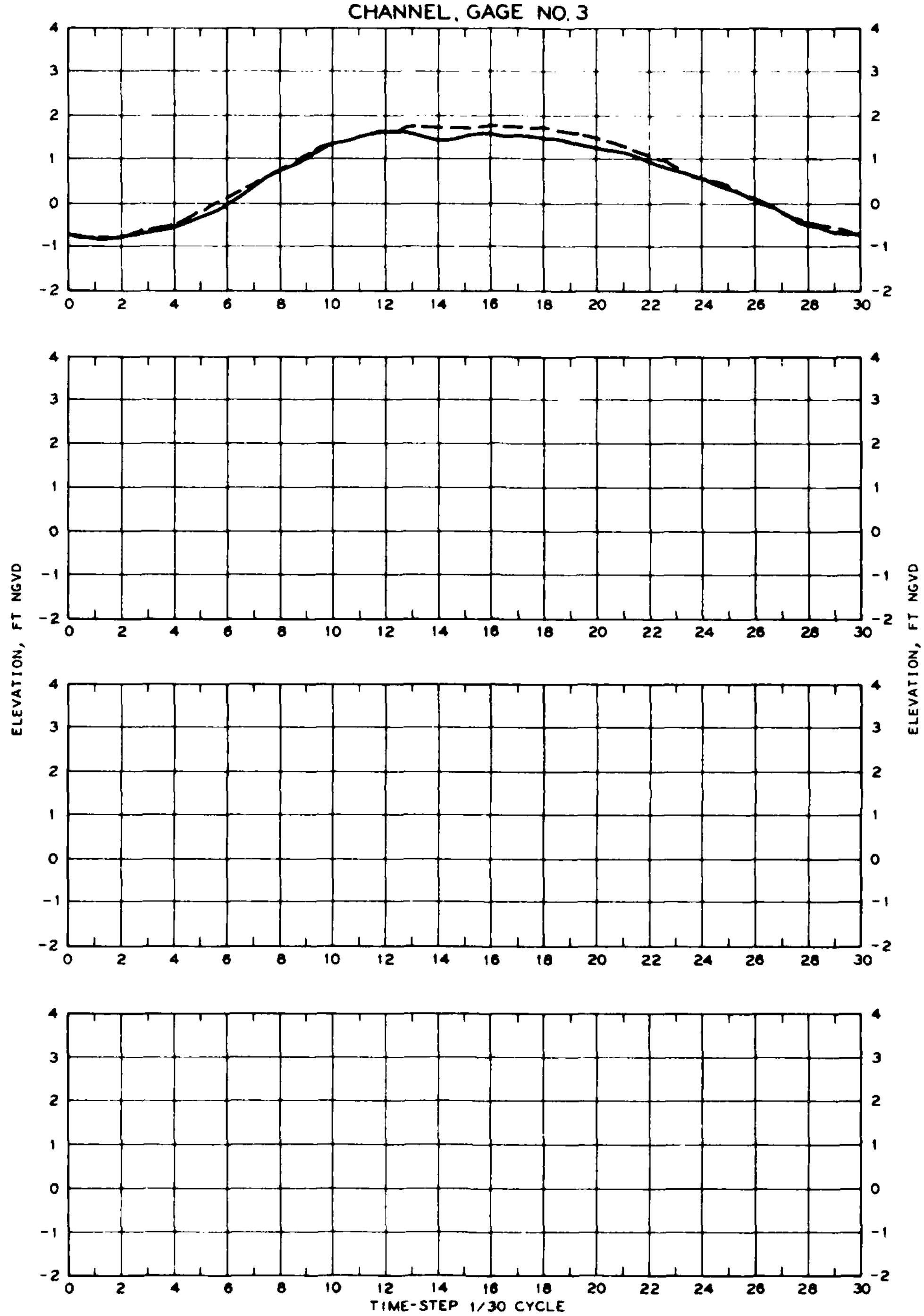
JETTY DOOR TEST
TIDAL HEIGHTS
MEAN TIDE
GAGES OCEAN, 2, 4, AND 1



JETTY DOOR TEST
TIDAL HEIGHTS
MEAN TIDE
GAGE 3



JETTY DOOR TESTS
TIDAL HEIGHTS
SPRING TIDE
GAGES OCEAN, 2, 4, AND 1

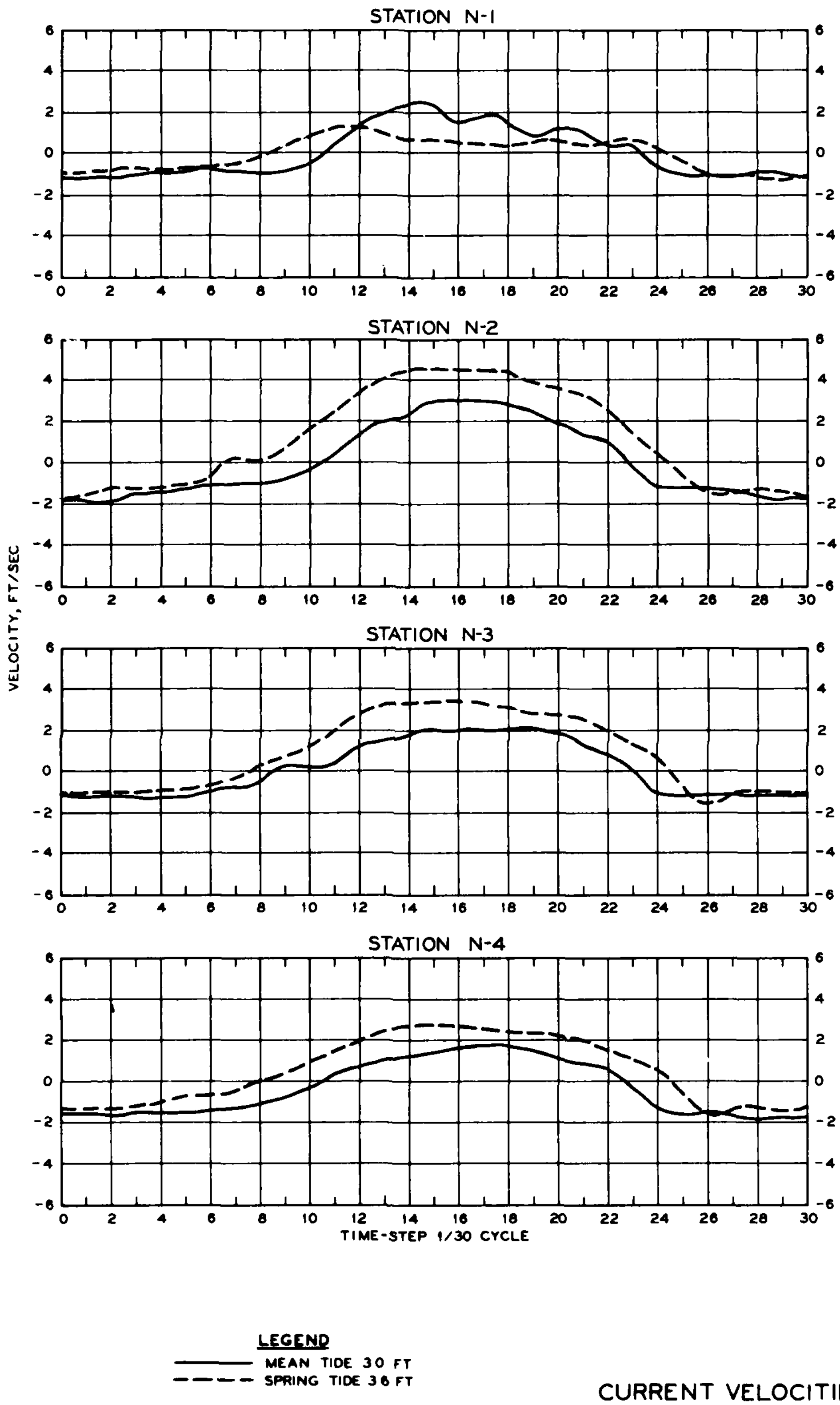


LEGEND

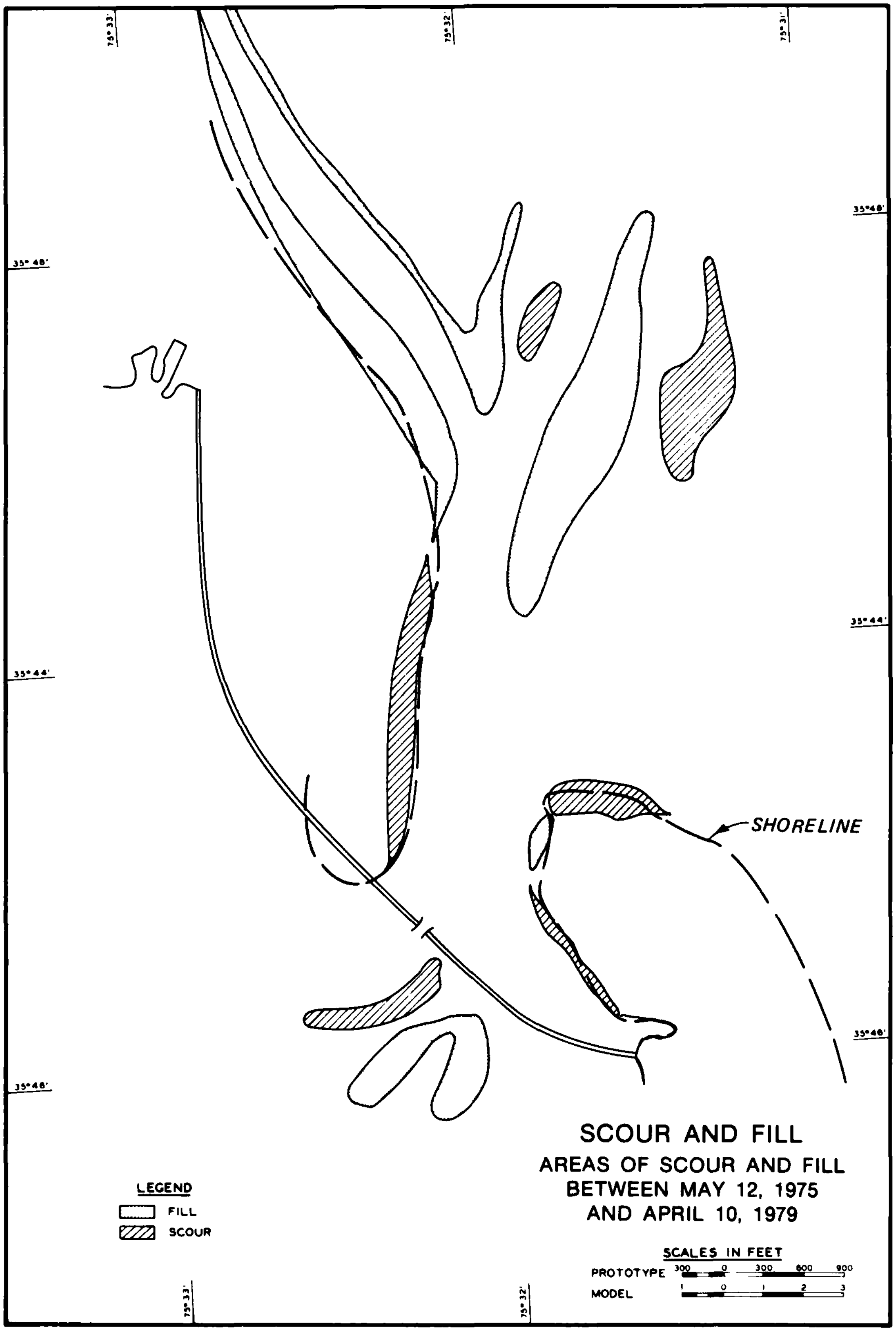
NORTH JETTY DOOR OPEN

SOUTH JETTY DOOR OPEN

JETTY DOOR TESTS
TIDAL HEIGHTS
SPRING TIDE
GAGE 3



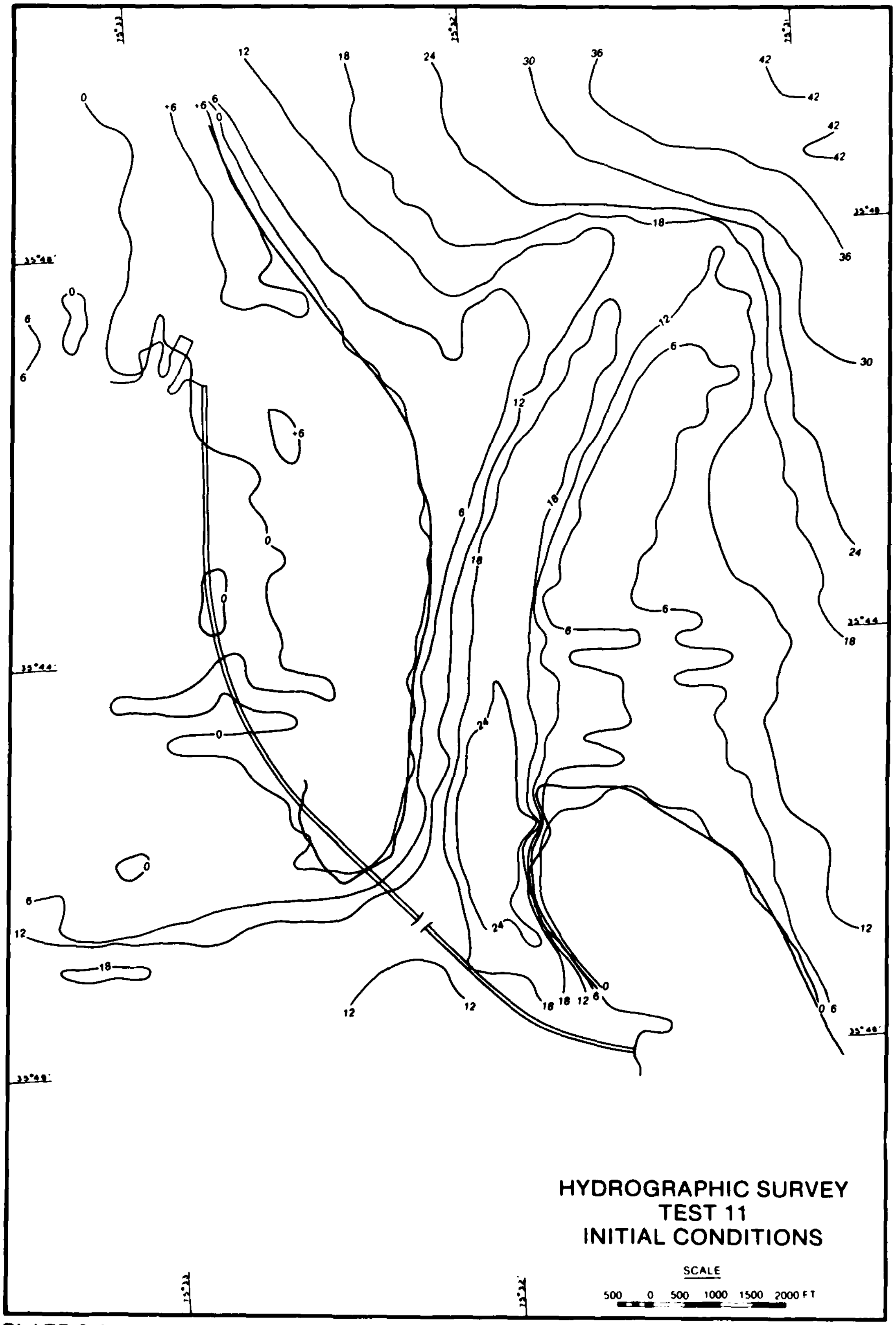
CURRENT VELOCITIES
JETTY DOOR TEST
STATIONS N1, N2, N3, AND N4



SCOUR AND FILL

AREAS OF SCOUR AND FILL
BETWEEN MAY 12, 1975
AND APRIL 10, 1979

PLATE 347



HYDROGRAPHIC SURVEY
TEST 11
INITIAL CONDITIONS

PLATE 348

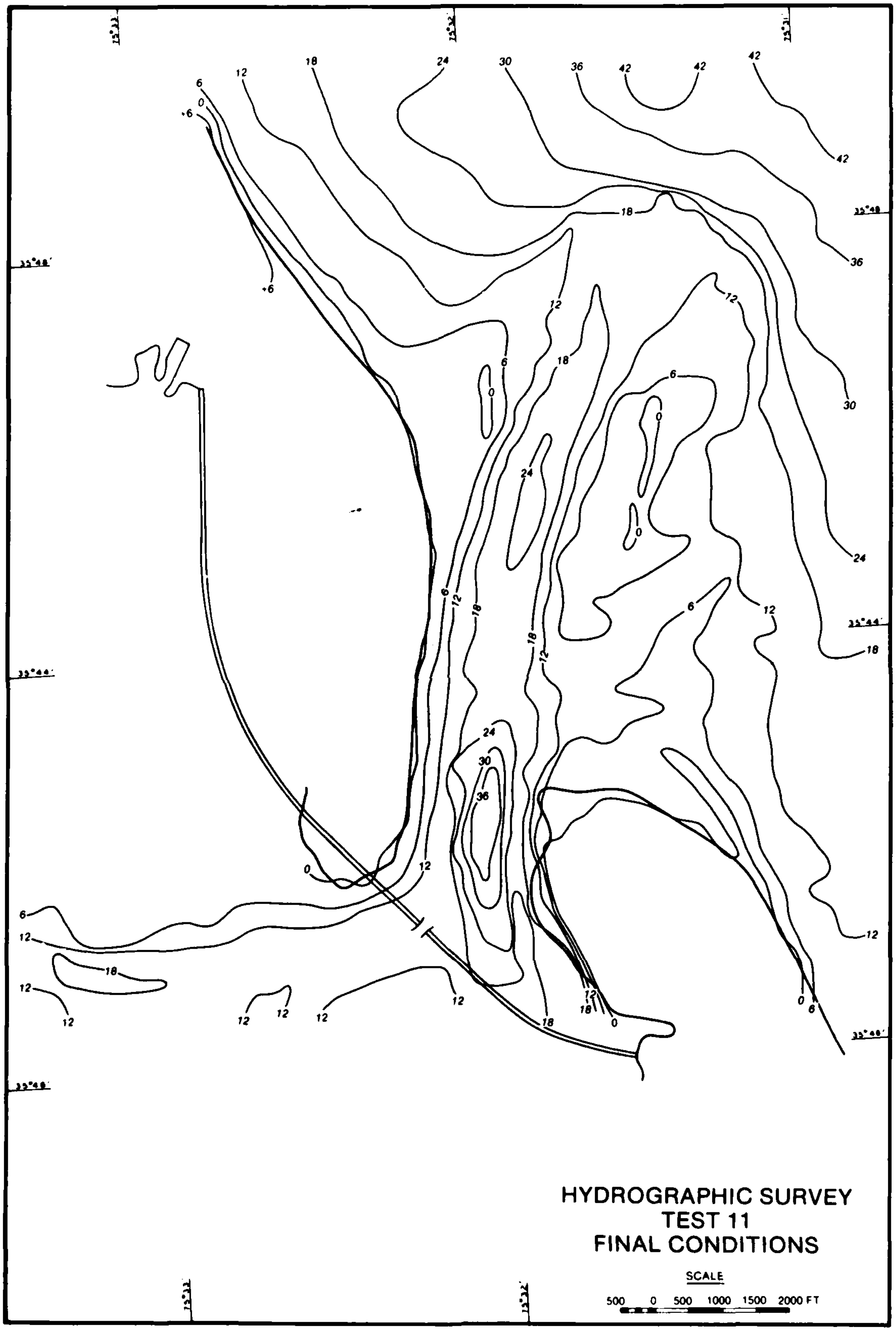
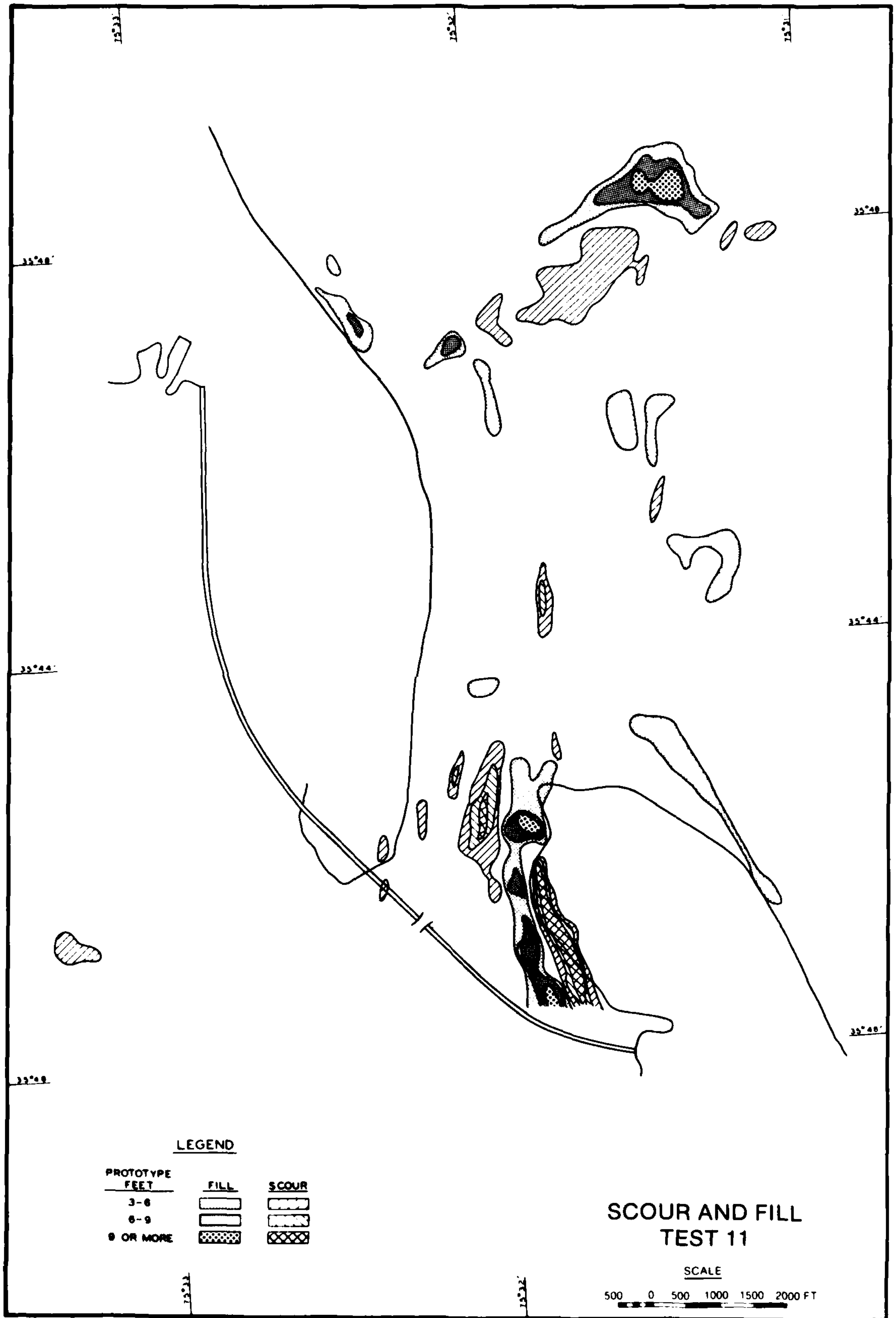

HYDROGRAPHIC SURVEY
TEST 11
FINAL CONDITIONS
SCALE
500 0 500 1000 1500 2000 FT

PLATE 349



LEGEND
PROTOTYPE FEET
FILL
SCOUR
3-6
6-9
9 OR MORE
SCOUR AND FILL
TEST 11
SCALE
500 0 500 1000 1500 2000 FT

PLATE 350

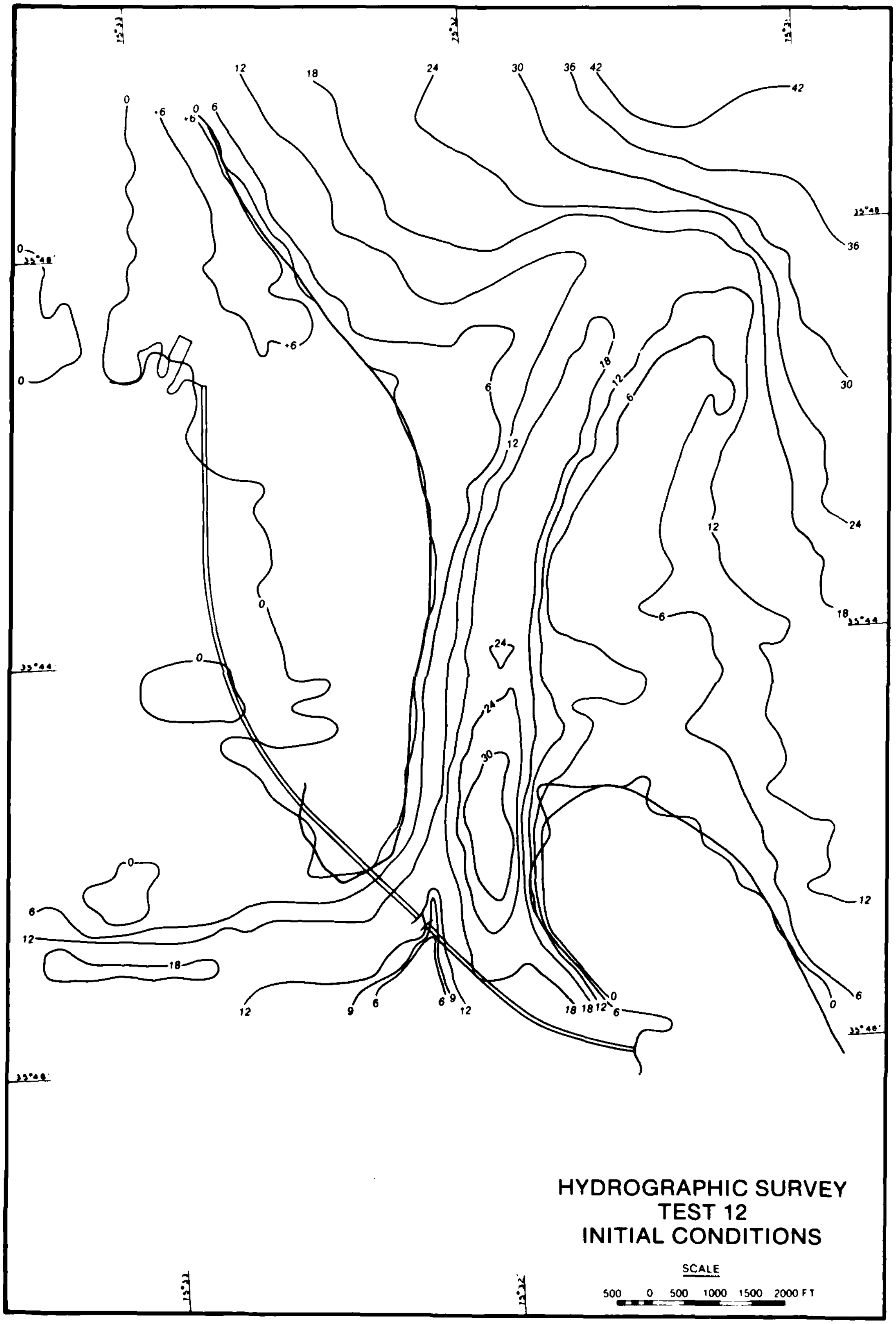

HYDROGRAPHIC SURVEY
TEST 12
INITIAL CONDITIONS
SCALE
500 0 500 1000 1500 2000 FT

PLATE 351

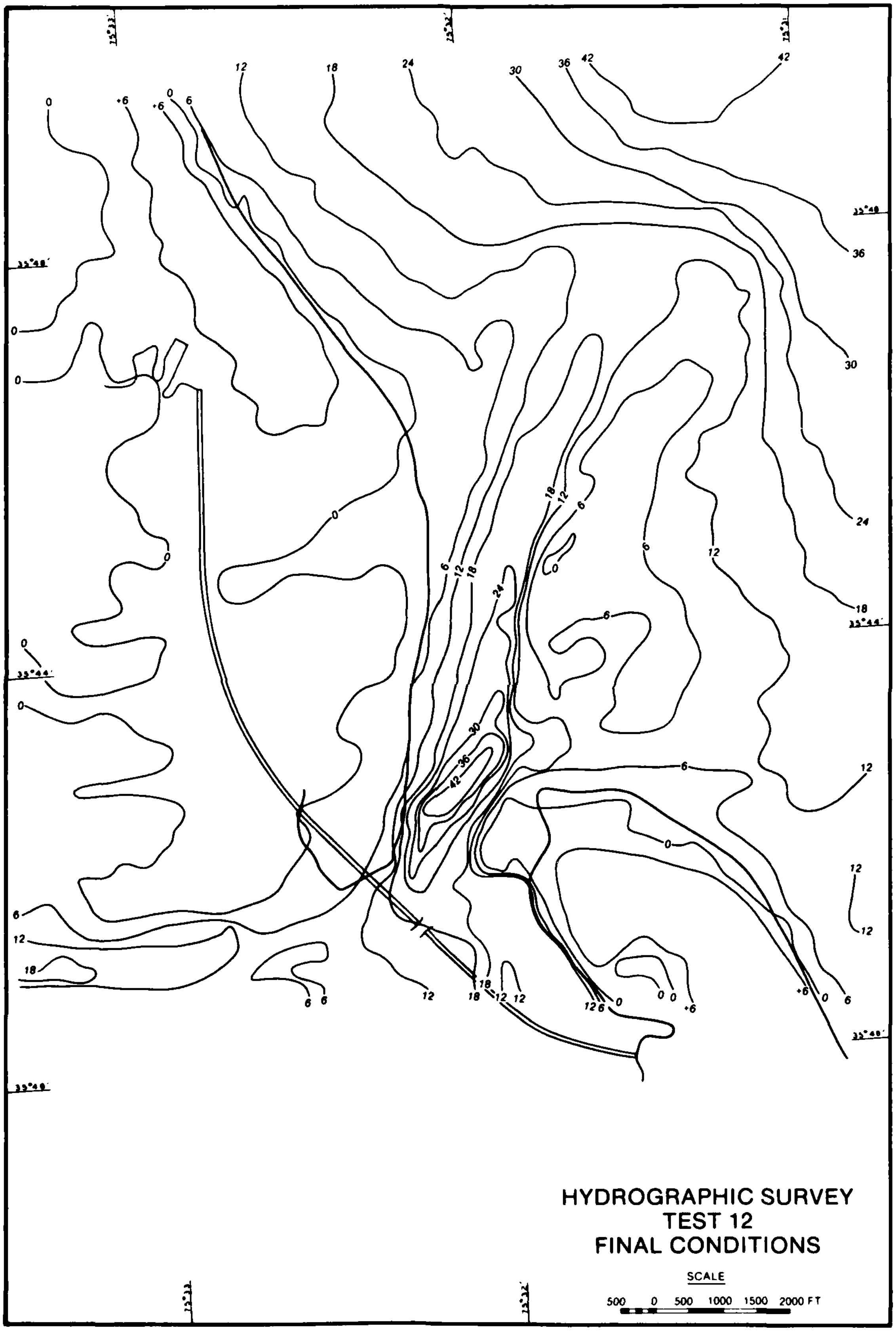

HYDROGRAPHIC SURVEY
TEST 12
FINAL CONDITIONS
SCALE
500 0 500 1000 1500 2000 FT

PLATE 352


LEGEND
PROTOTYPE FEET
FILL
SCOUR
3-6
6-9
9 OR MORE
SCOUR AND FILL
TEST 12
SCALE
500 0 500 1000 1500 2000 FT

PLATE 353

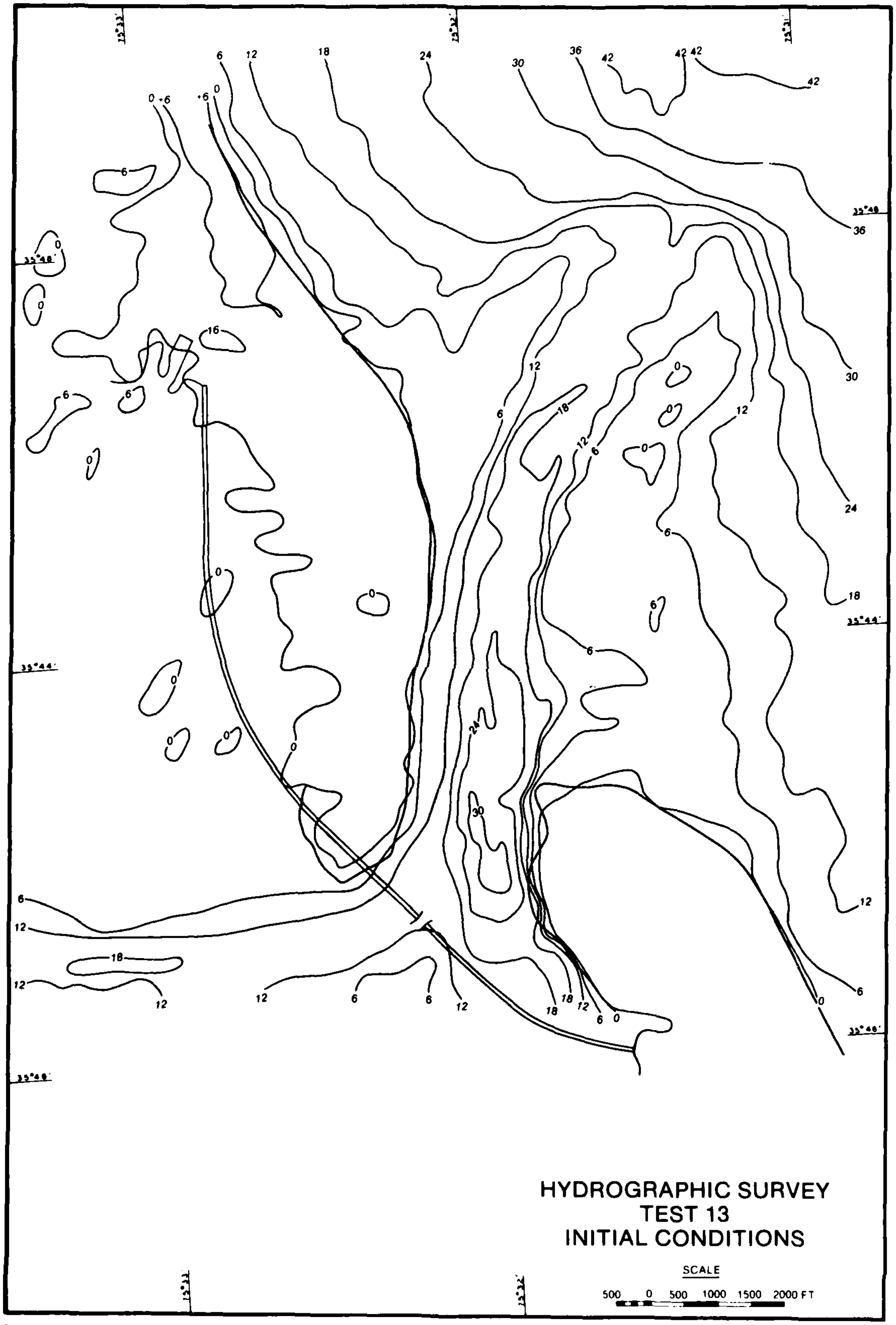

HYDROGRAPHIC SURVEY
TEST 13
INITIAL CONDITIONS
SCALE
500 0 500 1000 1500 2000 FT

PLATE 354

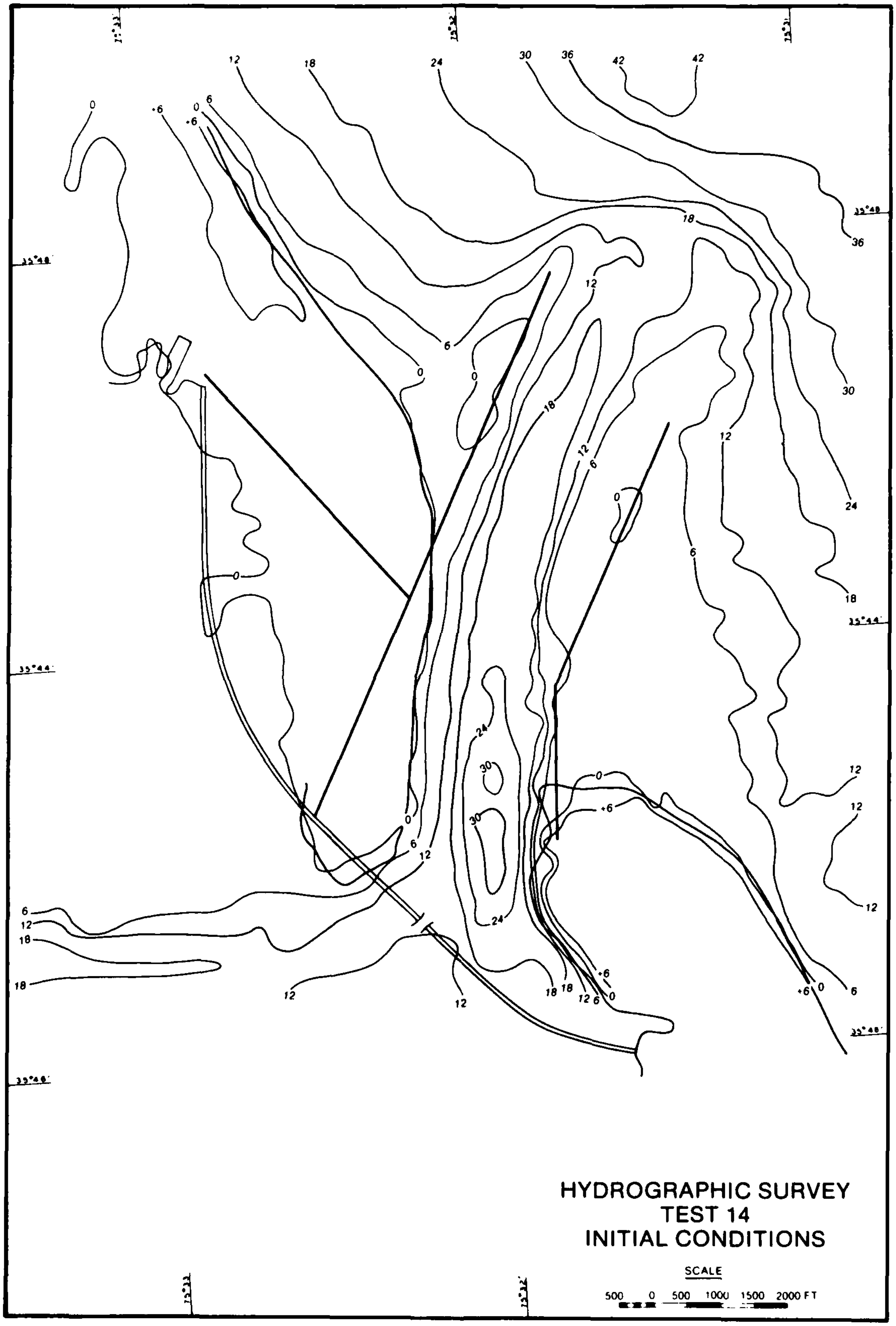
HYDROGRAPHIC SURVEY
TEST 13
FINAL CONDITIONS

SCALE
500 0 500 1000 1500 2000 FT

PLATE 355


LEGEND
PROTOTYPE FEET
FILL
SCOUR
3-6
6-9
9 OR MORE
SCOUR AND FILL
TEST 13
SCALE
500 0 500 1000 1500 2000 FT

PLATE 356



HYDROGRAPHIC SURVEY
TEST 14
INITIAL CONDITIONS

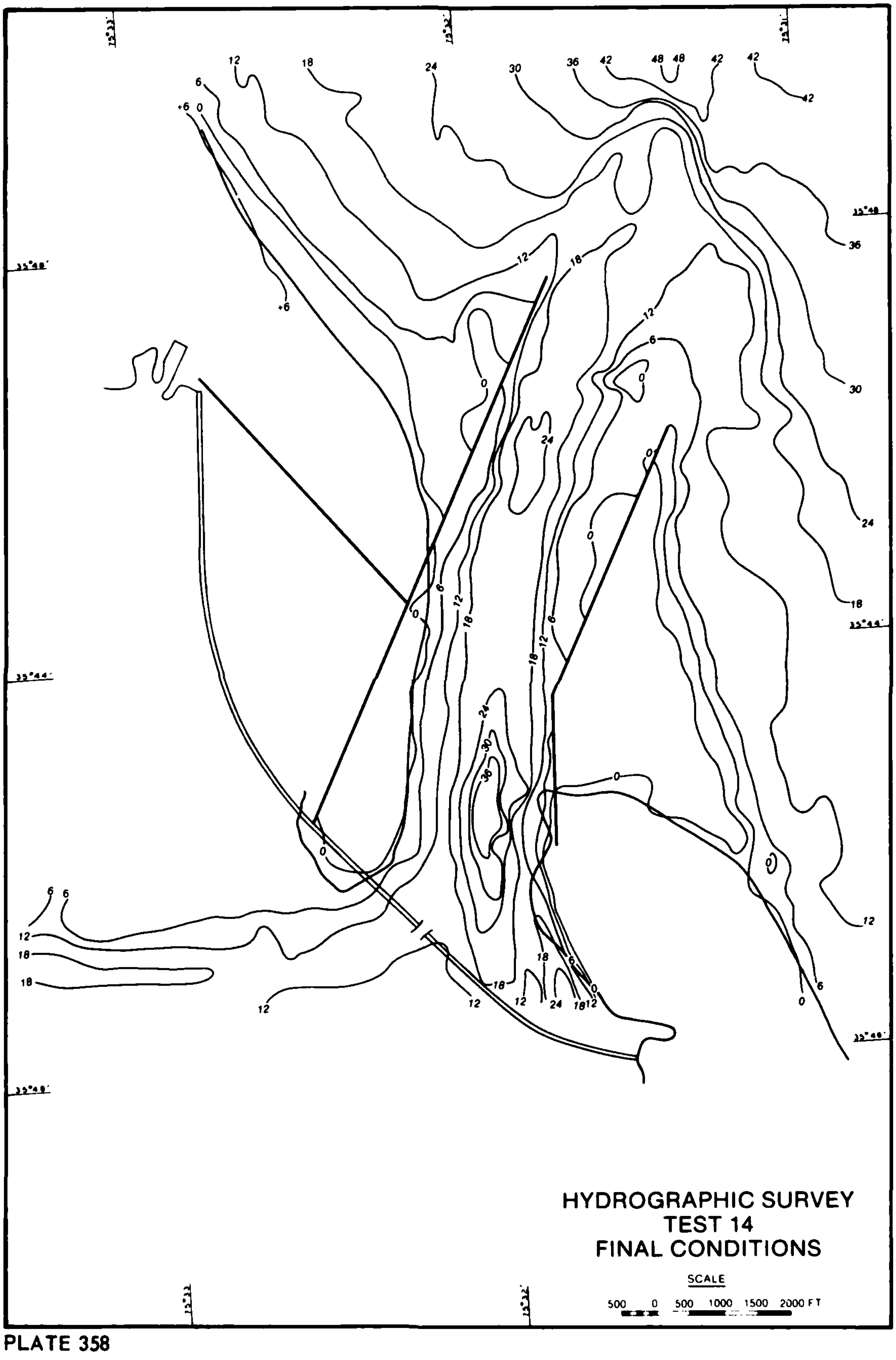

HYDROGRAPHIC SURVEY
TEST 14
FINAL CONDITIONS
SCALE
500 0 500 1000 1500 2000 FT

PLATE 358

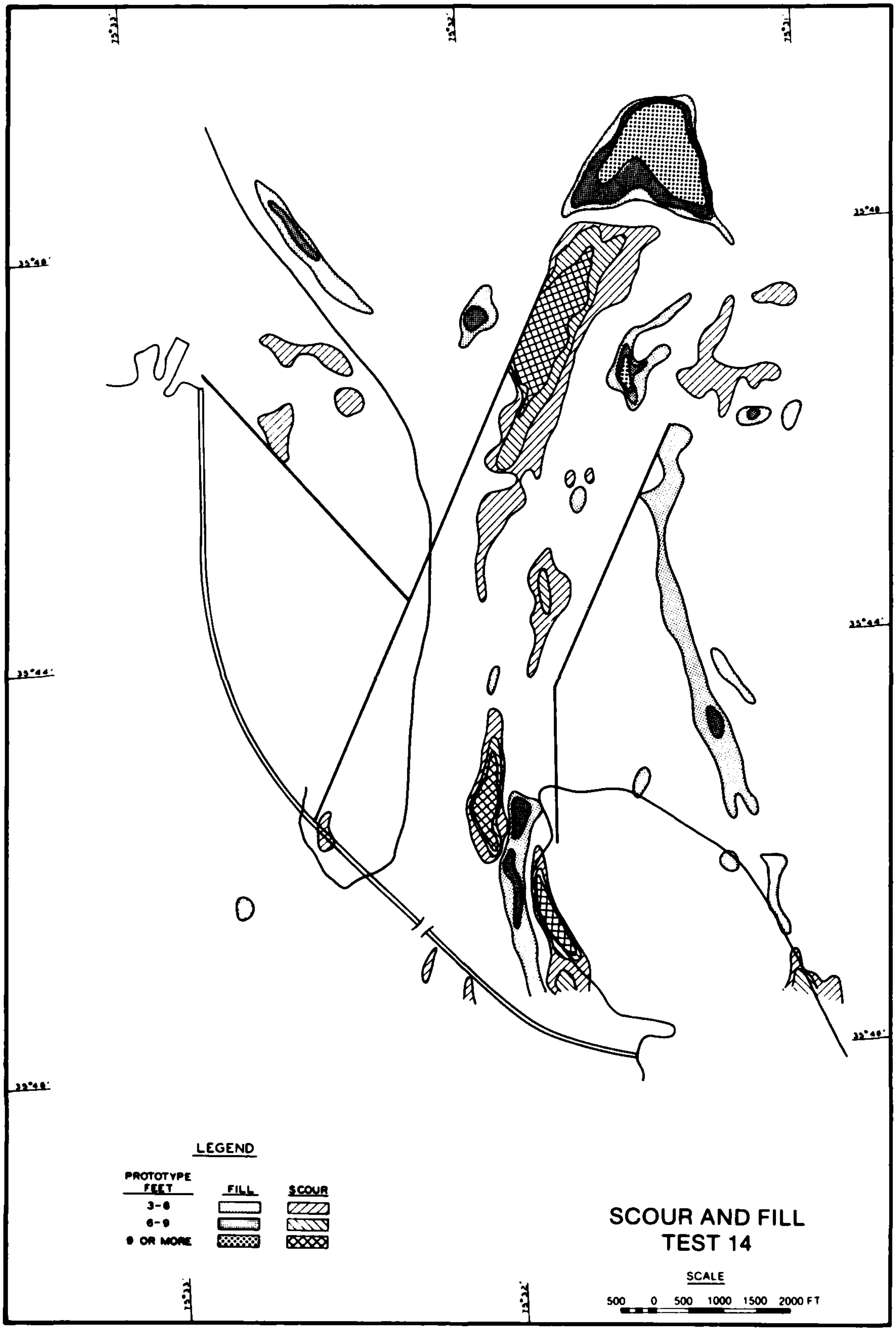
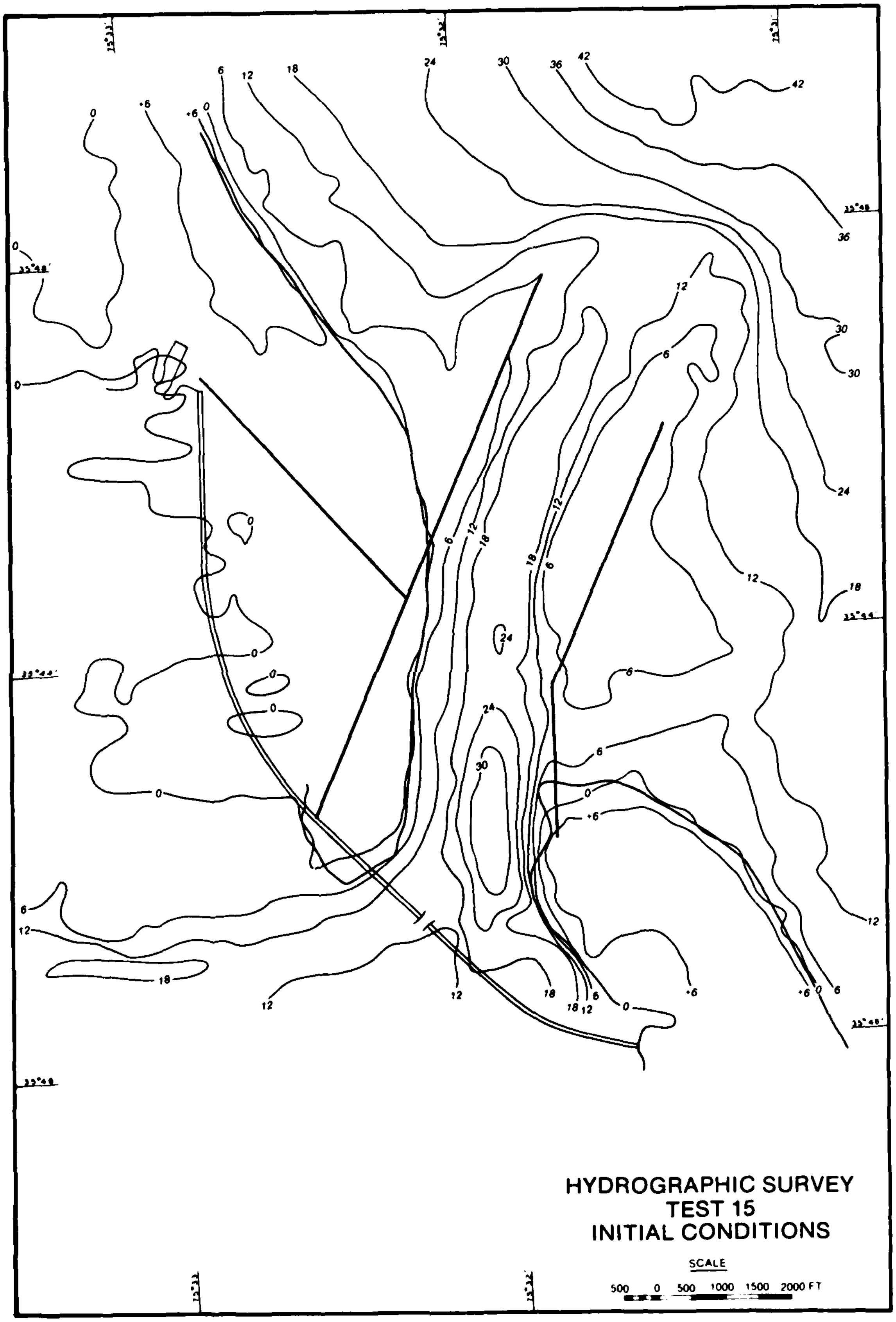

LEGEND
PROTOTYPE FEET
FILL
SCOUR
3-6
6-9
9 OR MORE
SCOUR AND FILL
TEST 14
SCALE
500 0 500 1000 1500 2000 FT

PLATE 359

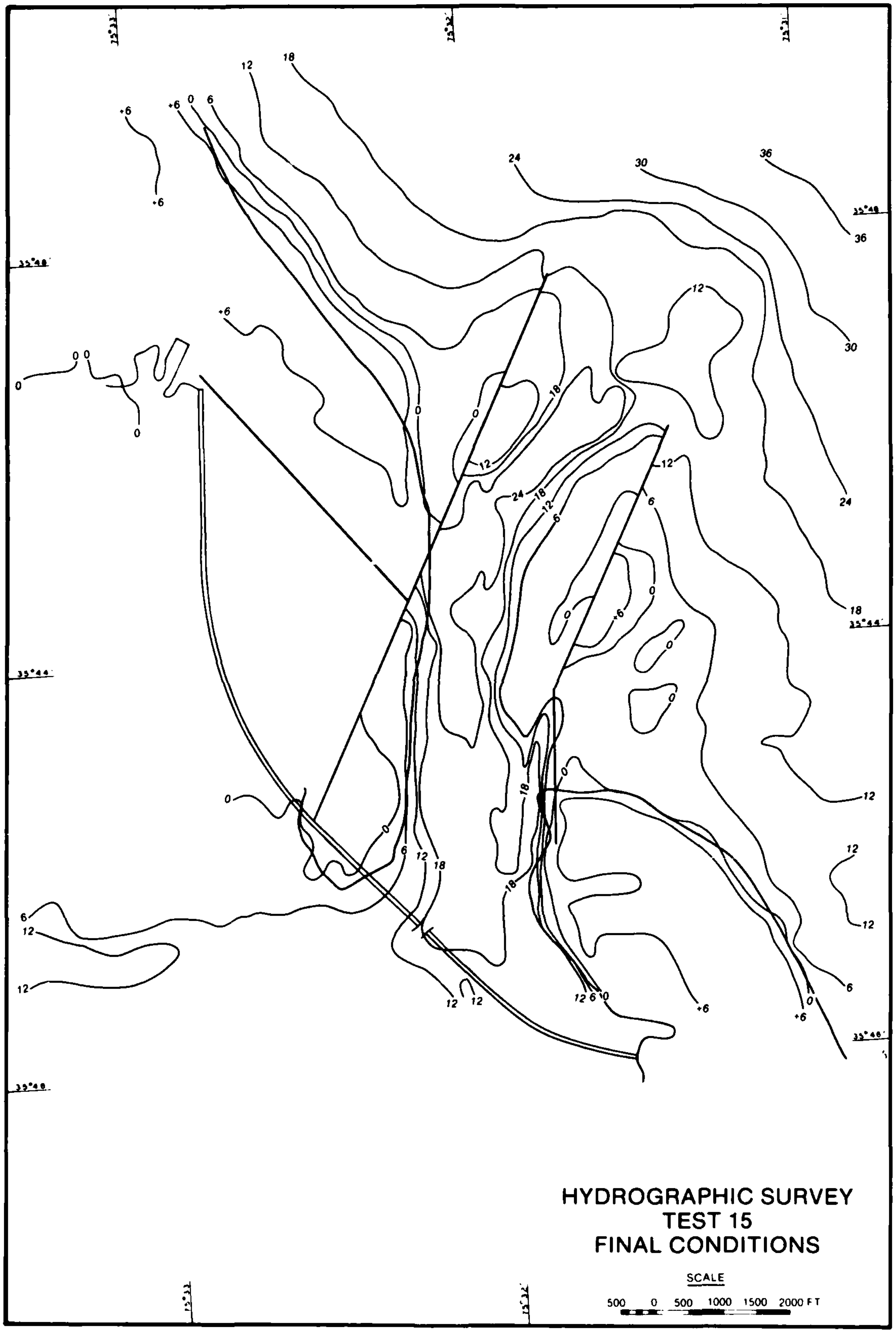


HYDROGRAPHIC SURVEY
TEST 15
INITIAL CONDITIONS

SCALE

500 0 500 1000 1500 2000 FT

PLATE 360


HYDROGRAPHIC SURVEY
TEST 15
FINAL CONDITIONS
SCALE
500 0 500 1000 1500 2000 FT

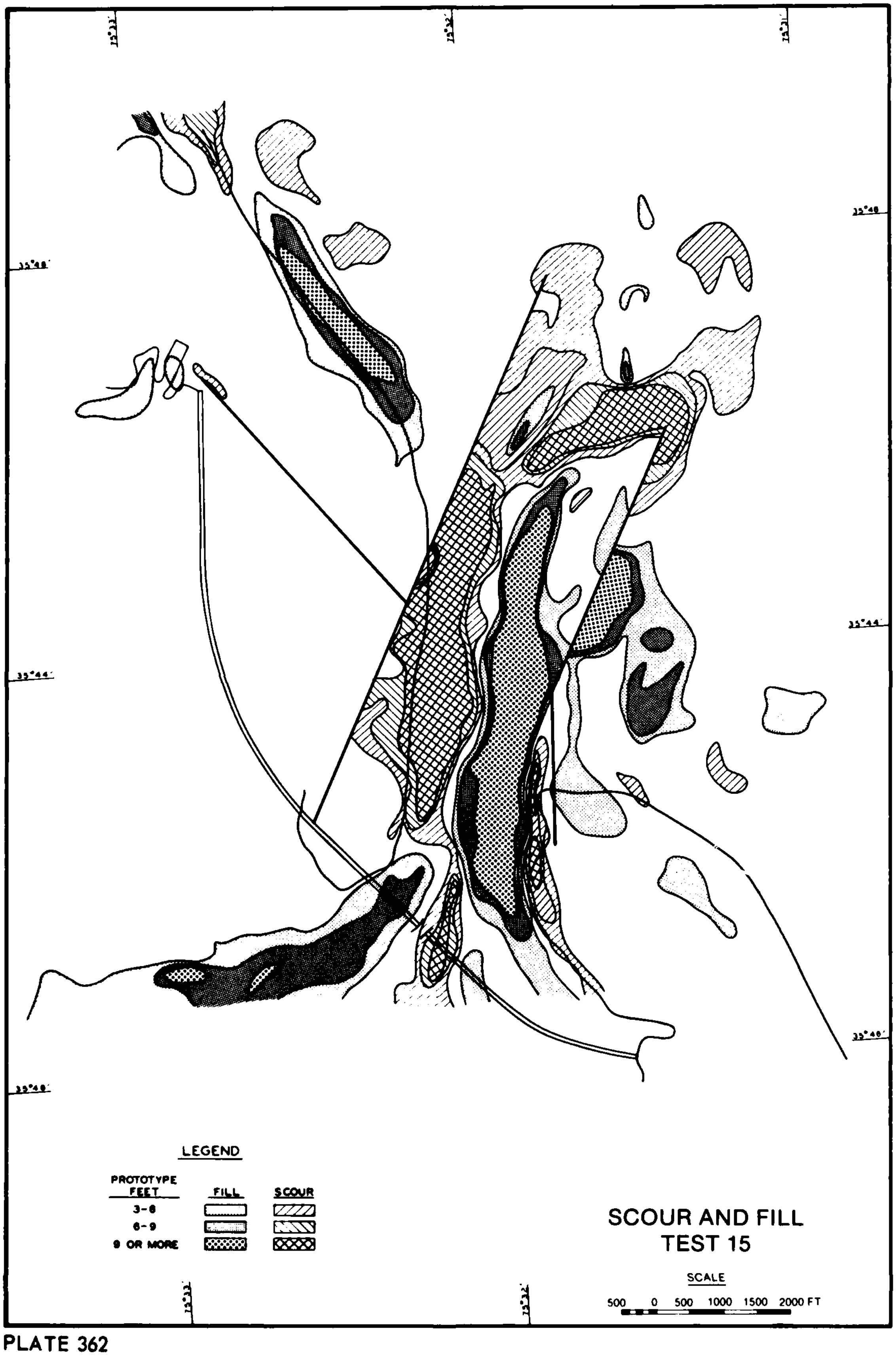
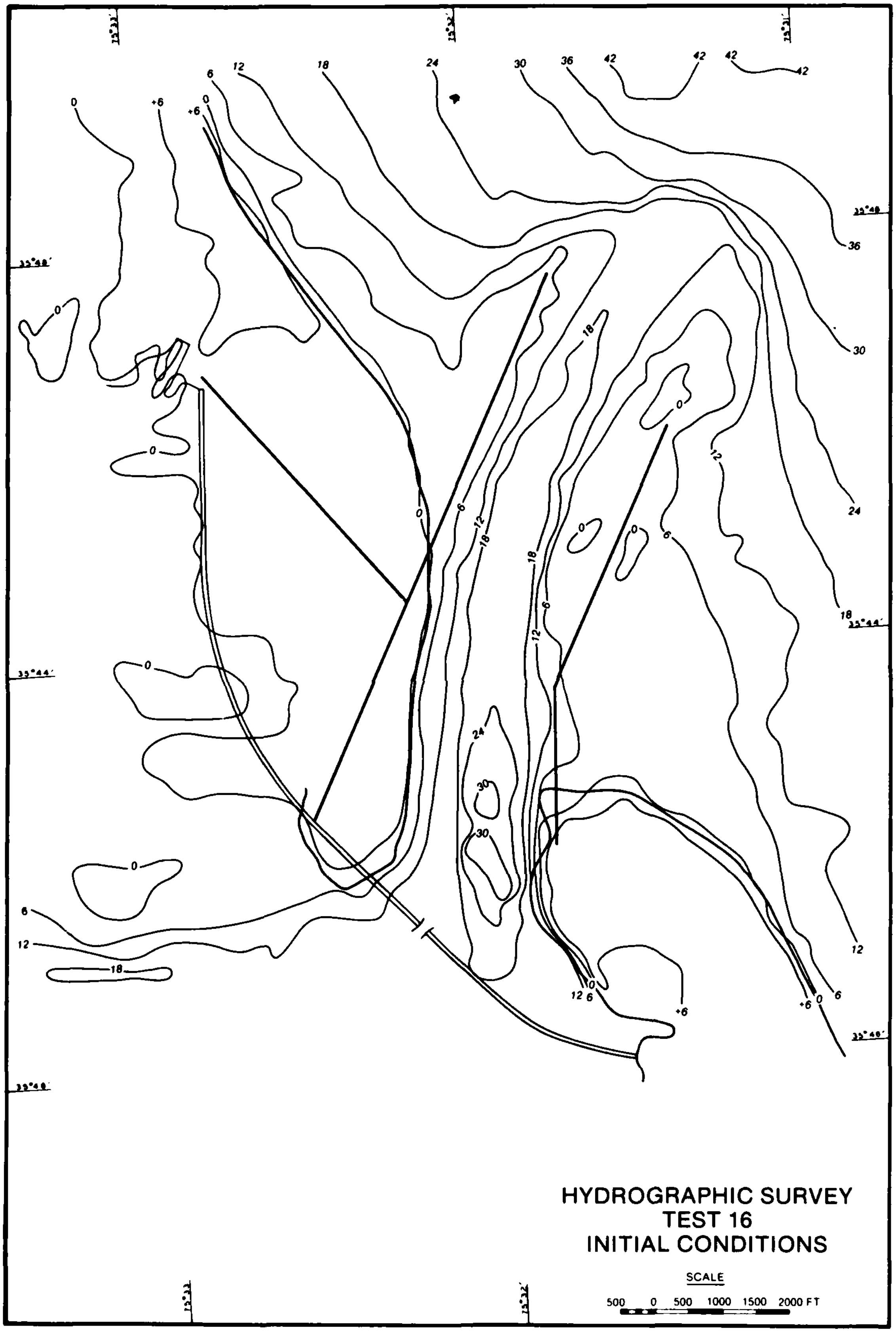
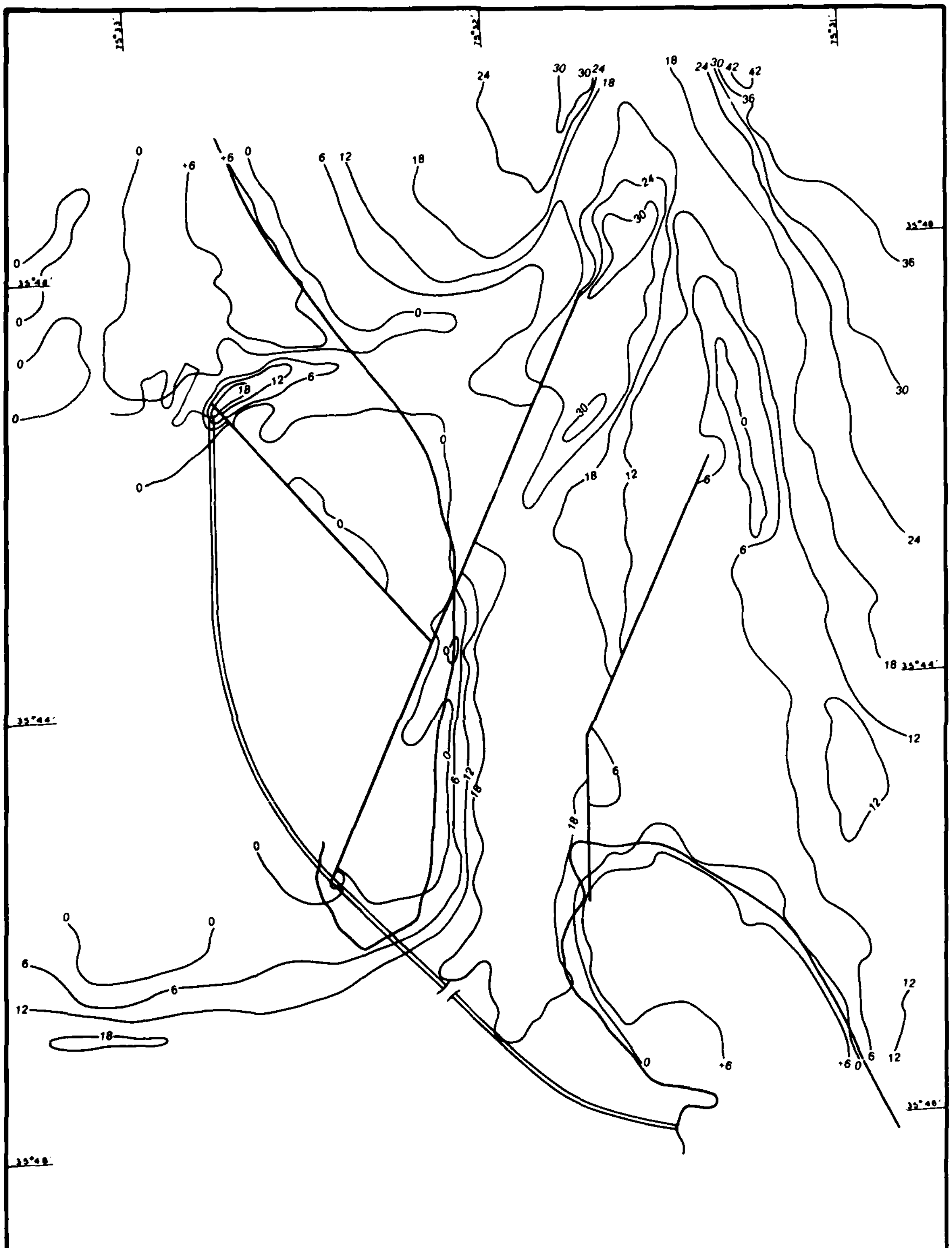

LEGEND
PROTOTYPE FEET
FILL
SCOUR
3-6
6-9
9 OR MORE
SCOUR AND FILL
TEST 15
SCALE
500 0 500 1000 1500 2000 FT

PLATE 362



HYDROGRAPHIC SURVEY
TEST 16
INITIAL CONDITIONS

PLATE 363



HYDROGRAPHIC SURVEY
TEST 16
FINAL CONDITIONS

SCALE

500 0 500 1000 1500 2000 FT

PLATE 364

SCOUR AND FILL
TEST 16

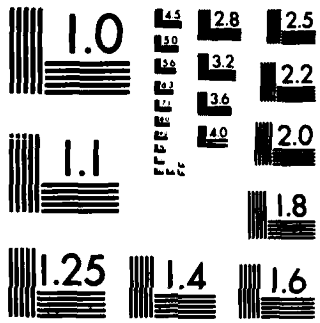
PLATE 365

AD-A131 999 HYDRAULIC MODEL INVESTIGATION: FUNCTIONAL DESIGN OF CONTROL STRUCTURES FO..(U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS HYDRA..

UNCLASSIFIED N W HOLLYFIELD ET AL. JUN 83 F/G 8/3 NL

INFORMATION

END
FILMED
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

SUPPLEMENTARY

INFORMATION

DEPARTMENT OF THE ARMY
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS
P.O. BOX 631
VICKSBURG, MISSISSIPPI 39180

REPLY TO
ATTENTION OF

WESAR

11 March 1985

AD-A131 999

Errata Sheet

No. 1

FUNCTIONAL DESIGN OF CONTROL STRUCTURES FOR
OREGON INLET, NORTH CAROLINA

Technical Report HL-83-10

June 1983

Page 1, third and fourth paragraphs: Replace these two paragraphs with the following.

SAW District Engineers during the model study and report preparation were COL Albert C. Costanzo, COL Homer Johnstone, COL Adolph A. Hight, and COL Robert K. Hughes.

Commanders and Directors of WES during the study and the preparation and publication of this report were COL John L. Cannon, CE, COL Nelson P. Connover, CE, and COL Tilford C. Creel, CE. Technical Director was Mr. F. R. Brown.

END

FILMED

5-85

DTIC